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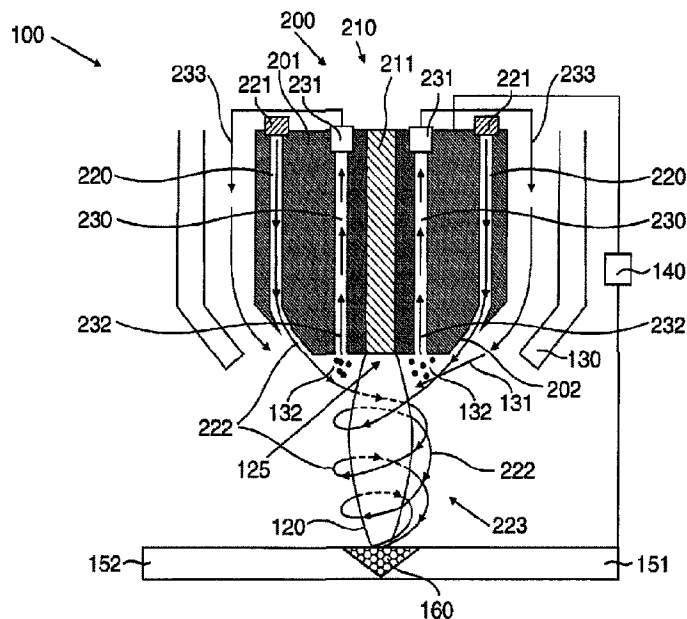
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(54) Titre : PROCEDE DE SOUDAGE AU TUNGSTENE SOUS PROTECTION GAZEUSE

(54) Title: A METHOD FOR TUNGSTEN SHIELDED WELDING



(57) **Abrégé/Abstract:**

The invention relates to a method for tungsten shielded welding, in particular tungsten inert-gas shielded welding, or for plasma welding, in which method an electrode (200) and a workpiece (151) are supplied with a welding current, the electrode (200) being supplied as the anode and the workpiece (151) as the cathode. An electric arc (120) is initiated and burns between an electric-arc-side face (202) of the electrode (200) and the workpiece (151) and the energy density of the electric-arc-side face (202) of the electrode (200) and/or the build up of the electric arc (120) on the electric-arc-side face (202) of the electrode (200) are deliberately influenced.

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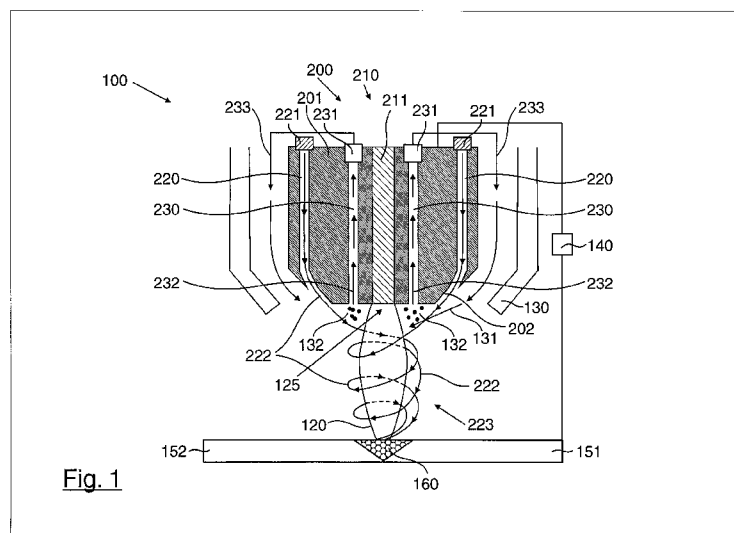


Fig. 1

(57) Abstract: The invention relates to a method for tungsten shielded welding, in particular tungsten inert-gas shielded welding, or for plasma welding, in which method an electrode (200) and a workpiece (151) are supplied with a welding current, the electrode (200) being supplied as the anode and the workpiece (151) as the cathode. An electric arc (120) is initiated and burns between an electric-arc-side face (202) of the electrode (200) and the workpiece (151) and the energy density of the electric-arc-side face (202) of the electrode (200) and/or the build up of the electric arc (120) on the electric-arc-side face (202) of the electrode (200) are deliberately influenced.

(57) Zusammenfassung:

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Die Erfindung betrifft ein Verfahren zum Wolfram-Schutzgasschweißen, insbesondere zum Wolfram-Inertgasschweißen oder zum Plasmaschweißen, wobei eine Elektrode (200) und ein Werkstück (151) mit einem Schweißstrom bestromt werden, wobei die Elektrode (200) als Anode und das Werkstück (151) als Kathode bestromt wird, wobei ein Lichtbogen (120) zwischen einer lichtbogenseitigen Fläche (202) der Elektrode (200) und dem Werkstück (151) initiiert wird und brennt, wobei eine Energiedichte der lichtbogenseitigen Fläche (202) der Elektrode (200) und/oder ein Lichtbogenansatz des Lichtbogens (120) an der lichtbogenseitigen Fläche (202) der Elektrode (200) gezielt beeinflusst werden.

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SpecificationA Method for Tungsten Shielded Welding

The invention relates to a method for tungsten shielded welding, in particular tungsten inert-gas shielded welding, or for plasma welding, wherein an electrode and a workpiece are supplied with a welding current, wherein the electrode is supplied as the anode and the workpiece as the cathode, wherein an electric arc is initiated and burns between an electric arc-side face of the electrode and the workpiece.

Prior Art

Tungsten shielded welding, in particular tungsten inert-gas shielded welding (WIG welding), and plasma welding involve a method for electric arc welding, for example which can be used for build-up welding, welding or soldering one, two or more workpieces made out of metallic materials. The workpiece and a tungsten electrode of a corresponding torch for tungsten shielded welding are here electrically connected with a welding current source. An electric arc burns between the tungsten electrode and the workpiece. The workpiece is here at least partially melted, and there forms the weld pool. In most materials, the tungsten electrode is used as the cathode, and the workpiece as the anode, wherein electrons pass from the tungsten electrode into the workpiece based on the physical current direction.

Plasma welding is a special version of tungsten inert-gas welding. In plasma welding, at least two independent gases or gas mixtures are supplied. Firstly, a plasma gas (also referred to as center gas) is used, which is (at least partially) ionized by the high temperature and high energy of the electric arc. As a consequence, the electric arc generates a plasma. In particular argon or a gas mixture of argon and shares of hydrogen or helium are used as the plasma

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gas. The outside gas here acts as a shielding gas. The use of helium or a helium-containing gas mixture as the shielding gas makes it possible to improve thermal conductivity and increase the energy input into the workpiece. However, helium is significantly more expensive by comparison to other shielding gases, and not available everywhere. In comparison to tungsten inert-gas welding, the disadvantage to plasma welding is that a corresponding torch for plasma welding is more complicated and expensive, and the larger torch detracts from accessibility and handling. For this reason, plasma welding can most often only be performed if automated.

Tungsten shielded welding most often utilizes rod-shaped electrodes comprised of pure tungsten or tungsten with additives of rare earth metals (e.g., lanthanum, cerium, yttrium), zirconium and thorium. These additives are most often present as oxides. The electrodes are sharply ground on the tool side for cathodic polarization. The mentioned additives in the tungsten reduce the work function of the electrons, so that the electrodes supplied as cathodes can be operated at very high currents.

Tungsten inert-gas welding or plasma welding with a negatively polarized tungsten electrode can only be conditionally used, if at all, for aluminum, aluminum alloys, bronze, magnesium, magnesium alloys, titanium or other materials that form high-melting oxides. The problem is that these high melting oxides are not dissolved. For this reason, the weld pool is hard to control, and it is difficult to observe the weld pool formation under the oxide layer. There is a danger of oxide inclusions. In addition, energy input into the component is slight.

The polarity of the tungsten electrode and the workpiece can be reversed by using the tungsten electrode as the anode and the workpiece as the cathode. In this case, the electrons pass from the workpiece into the tungsten electrode (physical

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current direction) These electrons exiting the workpiece or a corresponding ion bombardment can dissolve an oxide layer that forms or is present on the workpiece, thereby achieving a cleaning effect. This cleaning effect makes it possible to avoid oxide inclusions in the weld seam. In plasma welding with tap hole, this effect is intensified by comparison to tungsten inert-gas welding, for example, since the entire flanks of the joining parts come into contact with the plasma, and are effectively cleaned.

However, it is impossible or all but impossible to effectively and economically polarize the tungsten electrode as the anode in this way, since the capacity of the tungsten electrode supplied as the anode, in particular the thermal capacity and current carrying capacity, are highly limited. For example, the current carrying capacity of a tungsten electrode with a diameter of 3.2 mm typically measures between 20 A and 35 A.

Despite these low amperages, there is still a danger that the tungsten electrode will melt, and that melted material will detach from the tungsten electrode. This can lead to a destruction of the tungsten electrode and process fluctuations on the one hand, and to contaminations of the weld seam on the other, if melted material gets from the tungsten electrode into the weld pool of the workpiece.

Such contamination produces defects in the weld seam that can only be eliminated in a complex reworking process. The low current carrying capacity, and hence the low welding currents with which the tungsten electrode can be supplied, most often make it possible to achieve only a slight energy input into the workpiece. Therefore, the tungsten electrode can most often only be polarized as the anode in this way for very thin workpieces, or cannot be polarized at all due to the potential danger of tungsten inclusions. In addition, the welding speed is low.

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In order to increase the capacity of the electrode and simultaneously achieve a good cleaning effect, tungsten electrodes can be supplied with alternating current. For example, the current carrying capacity of a tungsten electrode with a diameter of 3.2 mm can be increased to approx. 200 A. However, power sources that provide this type of alternating current are very complicated and significantly more expensive than corresponding direct current sources. In addition, a strong acoustic burden is placed on the operator when operating the tungsten electrode with alternating current. Furthermore, more of a strain is put on the eyes of the welder, since the intensity of electric arc radiation continually varies due to the changing welding current. Beyond that, alternating current operation is also associated with the danger of the weld seam becoming contaminated. In addition, the energy introduced into the workpiece is reduced by comparison to a positively polarized tungsten electrode.

Prior art does offer ways for improving the thermal capacity of electrodes during tungsten shielded welding. However, these options are not suitable for improving the current carrying capacity of an electrode supplied as an anode during tungsten shielded welding. The basic idea underlying these concepts here most often has to do with efficiently dissipating the large amount of heat that hits the electrode. On the one hand, an attempt was made to improve cooling of the electrode, as described in DE 42 34 267 A1, DE 42 05 420 A1, DE 29 27 996A1 or US 3 569 661 A, for example.

On the other hand, a high melting insert can be introduced into a body made out of copper, and this insert can be cooled with water, as described in US 4 590 354 or DE 10 2009 059 108 A1 or DE 29 19 084 C2, for example. However, a corresponding insert is here used as the cathode. Completely different mechanisms are here at work than during use as the

tungsten shielded welding, in which the tungsten electrode is supplied as the anode.

A corresponding construction that is used as the anode is described in EP 0 794 696 B1 or US 3 242 305, for example. However, even these types of electrodes only exhibit a slight current carrying capacity, and using these types of electrodes at welding currents beyond the range of 20 A to 35 A ("high-current welding") is hardly possible, if not impossible.

The reason why is that a good cooling of the electrode supplied as the anode can lead to a point application of the electric arc on the anode, which can result in very high current densities, and thus to a destruction of the anode. Once this type of point electric arc application has been reached, anode material is evaporated, causing a self-amplifying effect to arise. The electric arc encounters especially favorable application conditions at the evaporation site, and focuses energy input on this location. Since the processes in the plasma take place faster than in a solid by orders of magnitude, even good thermal conduction and effective cooling are unable to prevent a destruction of the anode.

For this reason, it is desirable to improve tungsten shielded welding, in particular tungsten inert-gas welding or plasma welding, with an electrode supplied as an anode, in particular with an eye toward achieving an increased current carrying capacity for the electrode, especially for high current welding.

Disclosure of the Invention

This object is achieved with a method for tungsten shielded welding, in particular for tungsten inert-gas welding or plasma welding, having the features described herein.

Advantageous embodiments are the subject of the following description.

An electrode and a workpiece are supplied with a welding current, wherein the electrode is supplied as the anode, and the workpiece as the cathode. An electric arc is initiated between an electric arc-side face of the electrode and the workpiece and burns there. According to the invention, an energy density of the electric arc-side surface of the electrode and/or an electric arc application of the electric arc on the electric arc-side surface of the electrode are influenced in a targeted manner. As explained further below in detail, this makes it possible to significantly increase the current carrying capacity of the electrode.

During tungsten shielded welding, one, two or more workpieces made of metallic materials can be build-up welded, welded or soldered, or subjected to surface treatment, for example.

In particular, a shielding gas is supplied while welding. A corresponding welding torch in particular encompasses a shielding gas nozzle for supplying the shielding gas. The shielding gas directly influences the electric arc. A composition of the shielding gas can directly influence the efficiency of welding. In the case of a welding torch for plasma welding, this plasma torch alternatively or additionally encompasses a plasma gas nozzle for supplying a plasma gas, which is at least partially ionized.

Advantages of the Invention

In particular, influencing the energy density and/or electric arc application in a targeted manner avoids a point application of the electric arc on the electrode. This prevents high energy densities, in particular high current densities, which can destroy the electrode. In addition, the electrode is effectively cooled. As a consequence, a destruction of the electrode can be prevented. In addition,

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electrode is effectively cooled. As a consequence, a destruction of the electrode can be prevented. In addition, contamination or defects in the weld seam can be prevented, which can arise as the result of an extensively melted electrode.

Since the invention makes it possible to prevent high energy densities on the electrode and cools the electrode, the capacity of the electrode used as the anode can be increased. During tungsten shielded welding according to the invention, the electrode can be supplied with a lot higher amperages than is the case for conventional tungsten shielded welding. As a consequence, a cleaning effect of the workpiece can further be increased when using the electrode as the anode and the workpiece to be welded as the cathode. This causes an oxide layer that might have formed on the workpiece to dissolve with a high efficiency.

Therefore, the invention makes it possible to increase a current carrying capacity of the electrode supplied as the anode during tungsten shielded welding. The invention allows the electrode to be operated with welding amperages of up to 500 A. As a consequence, in particular a high current welding is carried out, and the electrode is used in particular as a high current anode. The electrode is preferably supplied with a welding current having an amperage of between 80 A and 500 A. Therefore, the invention enables a high current, positively polarized tungsten shielded welding, during which the anode can also be operated at high welding amperages.

The invention makes it possible to achieve a high energy input into the workpiece wired as the cathode. This high energy input is caused in particular by high drop voltages in the cathode drop area, as well as by the energy input by way of ions. In addition, a high welding speed and deep weld penetration can be achieved. Even comparatively thick workpieces or components can be economically welded using

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the invention. Inclusions of oxides or electrode material in the workpiece can be avoided, since the surface of the workpiece wired as the cathode is effectively cleaned, and the electrode wired as the anode is not melted by the high thermal capacity.

A Lorentz force acting on the electric arc depends especially on the diameter of the electric light application on the anode and cathode (i.e., on the electrode and workpiece). The Lorentz force brings about a stability of an electric arc flow. In particular, this electric arc flow denotes a flow of energy between the electrode and workpiece, and is crucial for the stability of the process. The more stable and stronger this electric arc flow to the workpiece, the higher the energy input into the workpiece, and the more uniform the formation of the weld seam. In particular, influencing the energy density and/or electric arc application in a targeted manner can amplify this flow, thereby increasing the energy input into the workpiece to be welded and improving process stability.

In particular, the invention makes it possible to reliably and efficiently weld light metals like aluminum, aluminum alloys, magnesium, magnesium alloys, titanium or other materials, for example bronze. This is enabled in particular by the high energy input of a high current electric arc into the workpiece wired as the cathode.

In a first advantageous embodiment of the invention, the energy density and/or electric arc application are influenced in a targeted manner by choosing or using a material for a selected region of the electric arc-side surface of the electrode that differs from an electrode material of the remaining electrode. In particular, the electric arc-side surface of the electrode consists partially of the electrode material and partially of this material differing from the electrode material.

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This selected region can be used to influence the application of the electric arc in a targeted manner. In particular, the electric arc is applied directly to this region. In comparison to the electrode material, the material of the selected region or physical properties of this material (in particular the melting point, boiling point, electrical and thermal conductivity as well as work function) are selected in such a way that electric arc application favors this selected region. This is achieved in particular by virtue of the fact that the physical and geometric properties of this material are adjusted to the amperage. In particular, the physical and geometric properties are selected in such a way that the material is melted to a maximally marginal extent, but uniformly. This avoids the danger of a point application of the electric arc on the electrode itself, and the resultant melting of the electrode. Since electric arc application favors the selected region, the electrode is not heated as intensively as an electrode during conventional tungsten shielded welding. This makes it possible to prevent the destruction of the electrode along with contaminants or defects in the weld seam caused by an intensively melted electrode.

The material of the selected region that differs from the electrode material is preferably chosen as a function of an amperage of the welding current. A diameter of the selected region is preferably chosen as a function of an amperage of the welding current. In particular, a larger diameter is used for higher amperages. In particular, smaller diameters are used for materials with a lower work function. In particular, the electric arc is not applied pointwise, but rather uniformly as a result, and the electrode is not destroyed by excessively high energy densities.

A high melting material is preferably used as the material for the selected region. In particular, a higher melting material than the electrode material, further in particular

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a higher melting refractory metal is chosen as the electrode material for the selected region. Since the electric arc is applied in particular to the selected region, using a high melting material can prevent the material of the selected region from melting. As a consequence, the remaining electrode made out of comparatively low melting material is further prevented from melting.

Zirconium, carbon, rhenium, tantalum, yttrium, niobium, hafnium, pure tungsten or tungsten with additives consisting of rare earth metals (such as lanthanum, cerium, and yttrium), zirconium and/or thorium are preferably used as the material for the selected region. These additives in tungsten are present in particular as oxides.

When using hafnium, active gases like carbon dioxide or oxygen can especially advantageously also be used as the shielding gas, without the electrode being destroyed. During conventional tungsten shielded welding, the electrode would be destroyed due to the high oxygen affinity of active gases.

In an advantageous embodiment of the invention, the material for the selected region is used in the form of an insert in the electric arc-side surface of the electrode. Accordingly, use is made in particular of an electrode that exhibits at least one insert made out of the material differing from the electrode material. In particular, this insert is introduced into the electrode in such a way that the insert is situated at least partially on the electric arc-side surface of the electrode. The electric arc-side surface of the electrode is thus comprised partially of the electrode material and partially of the material of the insert, but can also consist entirely of a high melting material. The insert can here protrude out of the electrode, or form a closed surface with the remaining electrode.

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The insert can here be designed with a suitable geometric shape, for example cubical, square or cylindrical. In particular, this insert can extend over the complete axial extension of the electrode. In particular, the insert can further have only a limited extension in the axial direction of the electrode, and thus be situated only indirectly on the electric arc-side surface of the electrode, for example. In particular, the diameter, work function and melting point of the insert are adjusted to the amperages of the welding current to be achieved. In particular, these parameters are adjusted in such a way as to uniformly heat the insert during operation over the entire corresponding part of the electric arc-side surface of the electrode.

In a second advantageous embodiment of the invention, the energy density and/or electric arc application are influenced in a targeted manner by supplying a focusing gas to the electric arc-side surface of the electrode in the form of at least one focusing gas flow. In particular, the focusing gas is supplied in addition to a shielding gas and/or a plasma gas. In particular, the focusing gas is supplied in the form of a focusing gas flow. Focusing the electric arc is here understood to mean that the application of the electric arc is focused or moved on the electric arc-side surface of the electrode, i.e., constructed on a specific region of the electrode or moved over a specific surface. In particular, the quantity and composition of the focusing gas can be varied. Argon, helium or a mixture of argon and helium are preferably supplied as the focusing gas.

The supplied focusing gas or focusing gas flow here exerts a cooling effect on the electrode, in particular on the electric arc-side surface of the electrode. The focusing gas cools the electrode directly. In addition, the focusing gas or the pulsed focusing gas flow exerts a pressure on the electric arc, in particular on the electric arc application.

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As a consequence, the electric arc can be cooled in the edge regions. This cooling effect, the exerted pressure along with the physical and chemical properties of the focusing gas influence the application of the electric arc.

Depending on how the focusing gas flow is directed relative to the electrode or relative to the electric arc, the application of the electric arc can be focused on the electric arc-side surface of the electrode, and constricted on a specific region. As a consequence, the focusing gas also prevents the point application of the electric light on the electrode, or on the region of the electrode with a low melting point.

The focusing gas is preferably supplied in a targeted manner around the or around the selected region of the electric arc-side surface of the electrode in the form of the at least one focusing gas flow. By combining the suitable choice of the material differing from the electrode material for the selected region and the supply of suitable focusing gas, the electric arc is applied in particular distributed over the entire selected region, and the material of the selected region does not melt. In particular, the focusing gas is supplied to the electric arc. The focusing gas is preferably supplied on the electric arc application.

The focusing gas is preferably supplied in the form of the at least one focusing gas flow as a turbulent flow. A turbulent flow (also referred to as "swirl") is understood to mean that the focusing gas flow expands spirally or helically around an axis. This axis runs in particular in the direction of the axial extension of the electrode, further in particular in the direction of the expansion of the electric arc. In particular, this axis corresponds to an electric arc axis of the electric arc. In particular, the turbulent flow is thus helically directed around the electric arc. As a consequence, the direction of the turbulent flow

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consists of an overlap of a first direction tangential to this axis and a second, axial direction parallel to this axis.

In an advantageous embodiment, the focusing gas is supplied through several focusing gas boreholes, wherein the electrode exhibits these focusing gas boreholes for supplying the focusing gas on its electric arc-side surface. The focusing gas boreholes can here each exhibit varying diameters, geometries and distances relative to each other. Alternatively, the focusing gas boreholes can also be identically designed and/or arranged equidistantly from each other. In particular, the electrode exhibits at least four focusing gas boreholes. In particular, the torch encompasses a suitable focusing gas supply. In particular, the electrode can be connected with this focusing gas supply. The focusing gas supply is set up to supply the focusing gas through the focusing gas boreholes.

In a third advantageous embodiment of the invention, the energy density and/or electric arc application are influenced in a targeted manner by discharging a gas from the electric arc-side surface of the electrode. The gas is here discharged from a specific region before the electric arc-side surface of the electrode.

The electric arc heats the gas before the electric arc-side surface of the electrode. This heated gas is discharged via the gas discharge. In particular, the discharged gas is a shielding, plasma or focusing gas. As a consequence, shielding gas, which is also heated by the electric arc, can be discharged. In particular, gas can also be centrally supplied to generate a flow to the workpiece.

As a consequence, the gas that is heated by the electric arc and other thermal effects and accumulates before the electrode is discharged. This makes it possible to indirectly

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reduce the temperature of the gas before the electrode. Due to such a diminished gas temperature before the electrode, the electrode is not heated as intensively or can cool off more easily. Discharging the gas indirectly cools the electrode, and increases its thermal capacity.

In addition, local thermal fluctuations can thereby be prevented from arising in the gas before the electrode. As a consequence, electrodes can further be prevented from being locally heated more intensively in some regions than in other regions. The point application of the electric arc favors these types of locally overheated regions on the electrode. Therefore, discharging the gas also prevents a point application of the electric arc.

The discharged gas is preferably supplied as a shielding gas. As mentioned further above, in particular shielding gas is discharged. In the process of being returned, this gas can again be supplied as the shielding gas. This makes it possible to increase the average temperature of the shielding gas and energy input into the workpiece.

In an advantageous embodiment of the invention, the gas is discharged from the electric arc-side surface of the electrode through an axially running gas discharge borehole in the electrode. The electrode is here designed in particular as a hollow electrode. In particular, a corresponding torch encompasses a gas discharge. This gas discharge is set up in particular to discharge the gas from the electric arc-side surface of the electrode through the axially running gas discharge borehole of the electrode.

It is preferable to use an electrode made out of an electrode material with a high thermal conductivity, preferably copper and/or brass. It is especially preferable to use a mixed alloy of copper and tungsten. As a consequence, the electrode can be cooled very effectively, and additionally has a high

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melting point. Since the electric arc is applied in particular to the selected region discussed above, the electrode does not necessarily have to consist of a high-melting material, and the electrode can still be prevented from melting.

In an especially preferred embodiment of the invention, use is made of an electrode that exhibits at least one insert made out of the material differing from the electrode material and/or that exhibits the focusing gas boreholes on its electric arc-side surface for supplying the focusing gas and/or that exhibits the at least one axially running gas discharge borehole for discharging the gas from the electric arc-side surface of the electrode.

The insert is advantageously located essentially in the center of the electric arc-side surface of the electrode. In particular, the insert here comprises the center or a tip of the electrode.

The focusing gas boreholes are preferably arranged around the center of the electric arc-side surface of the electrode. In particular, the boreholes are arranged concentrically around the center. As a consequence, the supplied focusing gas focuses the application of the electric arc in particular on the center of the electric arc-side surface of the electrode.

The insert is preferably located essentially in the center of the electric arc-side surface of the electrode, and the focusing gas boreholes are preferably arranged around the insert. On the one hand, the insert causes the electric arc to be applied in the center of the electric arc-side surface of the electrode. On the other hand, the electric arc application is additionally focused on the center by the focusing gas.

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The electrode preferably tapers toward its electric arc-side surface. As a consequence, the electrode in particular exhibits a "tip". The electrode thus exhibits no rectangular or nearly rectangular edges between its electric arc-side surface and a side or shell surface. Therefore, the electric arc-side surface is slanted in relation to the shell surface, i.e., inclined by a specific angle to the shell surface. As a result, the electric arc application cannot rapidly skip from the electric arc-side surface onto the shell surface of the electrode.

Instead, the electric arc application can be shifted along the (slanted) electric arc-side surface. It is especially preferred that the insert here be located in the center of the electric arc-side surface of the electrode, and at least partially form the tip or tapered portion of the electrode. In particular, the electric arc application is focused onto this tip or onto the tapered portion by the insert and focusing gas. The application surface can become larger as amperage increases, so that the current density remains nearly identical.

In an advantageous embodiment of the invention, the focusing gas boreholes are designed in such a way that the supplied focusing gas or focusing gas flow expands in the form of the turbulent flow discussed above. Properties of the turbulent flow, for example a radius of curvature, a pitch and/or a gradient, can be set by configuring the focusing gas boreholes and focusing gas supply. For example, the turbulent flow properties are set by the number of focusing gas boreholes, by a geometry of the individual focusing gas boreholes, by an arrangement of the focusing gas boreholes in relation to the axis, in particular by an eccentricity of the focusing gas boreholes in relation to the axis, and/or by an arrangement of the focusing gas boreholes in relation to the workpiece.

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It is advantageous to arrange the insert in a hollow space inside of the electrode, in particular in a cylindrical hollow space. The largest possible shell surface is selected between the insert and remaining electrode, so as to ensure a good heat dissipation. In particular, the insert is overmolded or sintered with the base body of the remaining electrode, or pressed into the latter, in particular in a manufacturing process.

The electrode preferably encompasses several inserts. A first insert is here preferably located essentially in the center of the electric arc-side surface of the electrode. At least one additional insert is preferably arranged around this first insert. In particular, the electric arc is here applied to all inserts. This makes it possible to reduce the load placed on the individual inserts.

A shielding gas is preferably supplied while welding. Argon, helium or a mixture of argon, helium and/or oxygen and/or carbon dioxide are preferably supplied as the shielding gas. Accordingly, in particular pure argon, pure helium or a mixture of argon and oxygen, of argon and helium or of argon, helium and oxygen are supplied as the shielding gas.

In these mixtures, use is made in particular of oxygen shares of between 150 ppm and 1%, as well as helium shares of between 2% and 50%. Given a workpiece made out of high alloyed steel, in particular a shielding gas comprised of argon or helium and a respective share of up to 10% hydrogen are supplied. During plasma welding, analogous mixtures are used as the shielding gas. In addition, use is made in particular of the plasma gas and focusing gas comprised of the mentioned gas mixtures.

In particular, a corresponding torch encompasses a shielding gas nozzle for supplying the shielding gas. The shielding gas directly influences the electric arc. A composition of

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the shielding gas directly influences welding efficiency. In the case of a welding torch for plasma welding, a corresponding plasma welding torch alternatively or additionally encompasses in particular a plasma gas nozzle for supplying a plasma gas, which is at least partially ionized.

In particular, influencing the energy density and/or electric arc application in a targeted manner makes it possible to reduce the share of helium in the shielding gas or use an argon-oxygen mixture as the shielding gas. As a consequence, tungsten shielded welding can also be effectively used in locations with low helium resources. In addition, the production outlay and costs to the user can be reduced.

The electrode is advantageously cooled, in particular by means of a water cooling device. As a result, the electrode can be directly and/or indirectly cooled. This type of indirect cooling is realized in particular over large contact surfaces between the electrode and remaining welding torch. Direct cooling is realized in particular by allowing cooling water to flow against a wall or shell surface of the electrode.

Additional advantages and embodiments of the invention may be gleaned from the specification and attached drawing.

It goes without saying that the features mentioned above and yet to be described can be used not just in the respectively indicated combination, but also in other combinations or alone, without departing from the framework of the present invention.

The invention is schematically depicted in the drawing based on an exemplary embodiment, and will be described in detail below with reference to the drawing.

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Brief Description of the Drawings

Fig. 1 presents a schematic, side view of a welding torch for tungsten shielded welding, which is set up to implement a preferred embodiment of a method according to the invention.

Fig. 2 presents a schematic, perspective view of an electrode for a welding torch for tungsten shielded welding, which is set up to implement a preferred embodiment of a method according to the invention.

Embodiment(s) of the Invention

Fig. 1 schematically depicts a welding torch marked 100 for tungsten shielded welding, which is set up to implement a preferred embodiment of a method according to the invention. In this example, the welding torch 100 is designed as a welding torch for tungsten inert-gas welding. The welding torch 100 is used to weld a first workpiece 151 with a second workpiece 152 in a joining process.

The welding torch 100 exhibits an electrode 200. The workpieces 151 and 152 and the electrode 200 are electrically connected with a welding current source 140. As a consequence, the electrode 200 is supplied with a welding current. The electrode 200 is here used as the anode, the workpieces 151 and 152 as the cathode. An electric arc 120 is initiated between the electrode 200 and workpieces 151 and 152, and burns between the electrode 200 and workpieces 151 and 152. The electric arc 120 at least partially melts the first and second workpieces 151 and 152, thereby resulting in a weld pool 160.

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The welding torch 100 carries out high current welding, and the electrode 200 is used as the high current anode. The electrode 200 is here supplied with a welding current of between 80 A and 500 A.

The welding burner 100 further exhibits a shielding gas nozzle 130, so as to supply a shielding gas in the form of a shielding gas flow to the welding process in the direction of the electric arc 120 or in the direction of the weld pool 160, as denoted by reference number 131.

The electric arc 120 is applied to an electric arc-side surface 202 of the electrode 200. A material that differs from the electrode material of the remaining electrode is used for a selected region of this electric arc-side surface 202.

To this end, the interior of the electrode 200 exhibits an insert 210. The electrode is here made out of an electrode material 201, and the insert 210 consists of a material 211 different than the electrode material 201. The insert material 211 here has a higher melting point than the electrode material 201. In this example, the electrode 200 is made out of copper 201, and the insert 210 out of tungsten 211.

In this example, the insert 210 extends over the complete axial expansion of the electrode 200. The insert forms a portion of the electric arc-side surface 202 of the electrode 200 in the selected region. The insert is here located in the center of the electric arc-side surface 202. In addition, the electrode 200 tapers toward its electric arc-side surface 202.

If the electrode 200 and workpieces 151 and 152 are electrically connected with the welding current source 140, the electric arc application favors the insert 210 consisting

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of tungsten 211, and less so the remaining electrode 200 made out of copper. As a consequence, an application 125 of the electric arc 120 on the electrode 200 is influenced in a targeted manner. In addition, the energy density of the electric arc-side surface 202 of the electrode 200 is thereby influenced in a targeted manner. In particular, the electric arc 120 is applied directly to the insert 210, and hence in the center of the electric arc-side surface 202.

The electrode 200 also exhibits focusing gas boreholes 220. In the example on Fig.1, only two focusing gas boreholes 220 are shown for the sake of clarity. However, the electrode 200 preferably exhibits at least four, preferably six, eight, ten, twelve or fourteen, focusing gas boreholes 220. The focusing boreholes 220 are here arranged around the insert 210. The focusing gas boreholes 220 are connected with a focusing gas supply 221. The focusing gas supply 220 is used to supply a focusing gas in the form of a focusing gas flow 222 through the focusing gas boreholes 220 in the direction of the electric arc 120. For example, focusing gas boreholes 220 can also be accommodated in other components of the torch, e.g., the shielding gas nozzle. However, the effect takes place at the anodic electric arc application.

In particular argon is here supplied as the focusing gas. The focusing gas or focusing gas flow 222 focuses the electric arc 120, in particular the electric arc application 125. The focusing gas or focusing gas flow 222 focuses the electric light application 125 on the center of the electric arc-side surface 202 of the electrode 200 (in addition to the insert 210). In addition, the electrode 200, in particular the electric arc-side surface 202 of the electrode 200, is cooled by supplying the focusing gas or focusing gas flow 222. Furthermore, the energy density of the electric arc-side surface 202 of the electrode is influenced in a targeted manner as a result.

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The shielding gas can also be used for focusing by at least partially directing it toward the electrode 220, for example via screens. For this purpose, it is especially advantageous for the welding torch 100 to be designed in such a way that the electrode 200 protrudes out of the shielding gas nozzle 130. As a consequence, the electric arc 120 can be ignited more easily, and accessibility and observability of the process can be improved.

The focusing boreholes 220 are arranged in the electrode 200 in such a way that the focusing gas flow 22 forms as a turbulent flow (also referred to as "swirl"). As a consequence, the focusing gas flow 222 is directed around the electric arc 120 as a spiral or helical shape 223.

In addition, the electrode 210 exhibits two axially running gas discharge boreholes 230. The electrode 210 is hence designed as a hollow electrode. In this example, the gas discharge boreholes 230 run parallel to the insert 210. A gas discharge borehole can also be formed in the insert 210.

The electric arc 120 or thermal effect of the electric arc 120 heats the supplied shielding gas. As a consequence, heated shielding gas 132 accumulates before the electric arc-side surface 202 (denoted by points). The gas discharge boreholes 230 are connected with a gas discharge 231. The gas discharge 231 discharges the heated shielding gas 132 from the electric arc-side surface 202, as denoted by reference number 232.

Discharging the heated shielding gas 132 cools the electrode 200, in particular the electric arc-side surface 202 of the electrode 200. As a consequence, the application 125 of the electric arc 120 on the electrode 200 and energy density of the electric arc-side surface 202 of the electrode 200 can be influenced in a targeted manner.

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In addition, the discharged shielding gas 232 can be supplied to the welding process anew through the gas discharge 231 as a shielding gas or focusing gas 222. The returned shielding gas is shown on Fig. 1 and denoted with reference number 233.

Fig. 2 presents a schematic, perspective view of another electrode 200, which can be used to implement a preferred embodiment of a method according to the invention. Identical reference numbers on Fig. 1 and 2 denote structurally identical elements.

The electrode on Fig. 2 exhibits an insert 210 and a plurality of focusing gas boreholes 220. The insert is located in the center of the electric arc-side surface 202 of the electrode 200. The focusing gas boreholes 220 are here circularly arranged around the insert 210.

Reference List

- 100 Welding torch
- 120 Electric arc
- 125 Electric arc application
- 130 Shielding gas nozzle
- 131 Shielding gas flow
- 132 Heated shielding gas
- 140 Welding current source
- 151 First workpiece
- 152 Second workpiece
- 160 Weld pool

- 200 Electrode
- 201 Electrode material, copper
- 202 Electric arc-side surface
- 210 Insert
- 211 Insert material, tungsten
- 220 Focusing gas borehole
- 221 Focusing gas supply
- 222 Focusing gas flow
- 223 Spiral shape, helical shape
- 230 Gas discharge boreholes
- 231 Gas discharge
- 232 Discharged shielded gas
- 233 Returned shielded gas

Claims

1. A method for tungsten inert-gas welding,
 - wherein a welding current is applied to an electrode and a workpiece, wherein current is applied to the electrode as an anode and to the workpiece as a cathode,
 - wherein an electric arc is initiated and burns between an arc-side surface of the electrode and the workpiece,wherein
 - an energy density of the arc-side surface of the electrode and/or an arc striking point of the arc on the arc-side surface of the electrode are specifically influenced, in that a focusing gas in the form of at least one focusing gas flow is supplied to the arc-side surface of the electrode, wherein a shielding gas is additionally supplied through a shielding gas nozzle during welding, wherein the electrode protrudes out of the shielding gas nozzle.
2. The method according to Claim 1, wherein one or more of the energy density and the arc striking point are specifically influenced, in that a material that differs from an electrode material of the remaining electrode is used for a selected region of the arc-side surface of the electrode.
3. The method according to Claim 2, wherein one or more of the material that is different from the electrode material and a diameter of the selected region is chosen in dependence on a current intensity of the welding current.
4. The method according to Claim 2 or 3, wherein a high-melting point material, which is higher-melting than the electrode material, is used as the material for the selected region.
5. The method according to any one of Claims 2 to 4, wherein zirconium, carbon, rhenium, tantalum, yttrium, niobium, hafnium, tungsten or tungsten with an addition of one or more of lanthanum, cerium and thorium is used as the material for the selected region.
6. The method according to any one of Claims 2 to 5, wherein the material for the selected region is used in the form of an insert in the arc-side surface of the electrode.

7. The method according to any one of Claims 1 to 6, wherein the focusing gas in the form of the at least one focusing gas flow is supplied specifically one or more of around the selected region of the arc-side surface of the electrode and to the arc striking point.
8. The method according to any one of Claims 1 to 7, wherein the focusing gas in the form of the at least one focusing gas flow is supplied as a turbulent flow.
9. The method according to any one of Claims 1 to 8, wherein argon, helium or a mixture of argon and helium and the argon, helium or the mixture of argon and helium with additions of oxygen are supplied as the focusing gas.
10. The method according to any one of Claims 1 to 9, wherein the focusing gas is supplied through multiple focusing gas bores, wherein the electrode has these focusing gas bores for supplying the focusing gas on its arc-side surface.
11. The method according to any one of Claims 1 to 10, wherein one or more of the energy density and the arc striking point are specifically influenced, in that the shielding gas is removed from the arc-side surface of the electrode.
12. The method according to Claim 11, wherein the gas is removed from the arc-side surface of the electrode through at least one axially extending gas removal bore in the electrode.
13. The method according to any one of Claims 1 to 12, wherein argon, helium or a mixture of argon, one or more of helium and oxygen, or carbon dioxide, is supplied as the shielding gas.
14. The method according to any one of Claims 1 to 13, wherein the electrode is cooled.
15. The method according to Claim 14, wherein the electrode is cooled by means of a water cooling device.
16. The method according to any one of Claims 1 to 15, wherein one or more of a high-current reverse-polarity welding is carried out and a welding current with a current intensity of between 80 A and 500 A, is applied to the electrode.

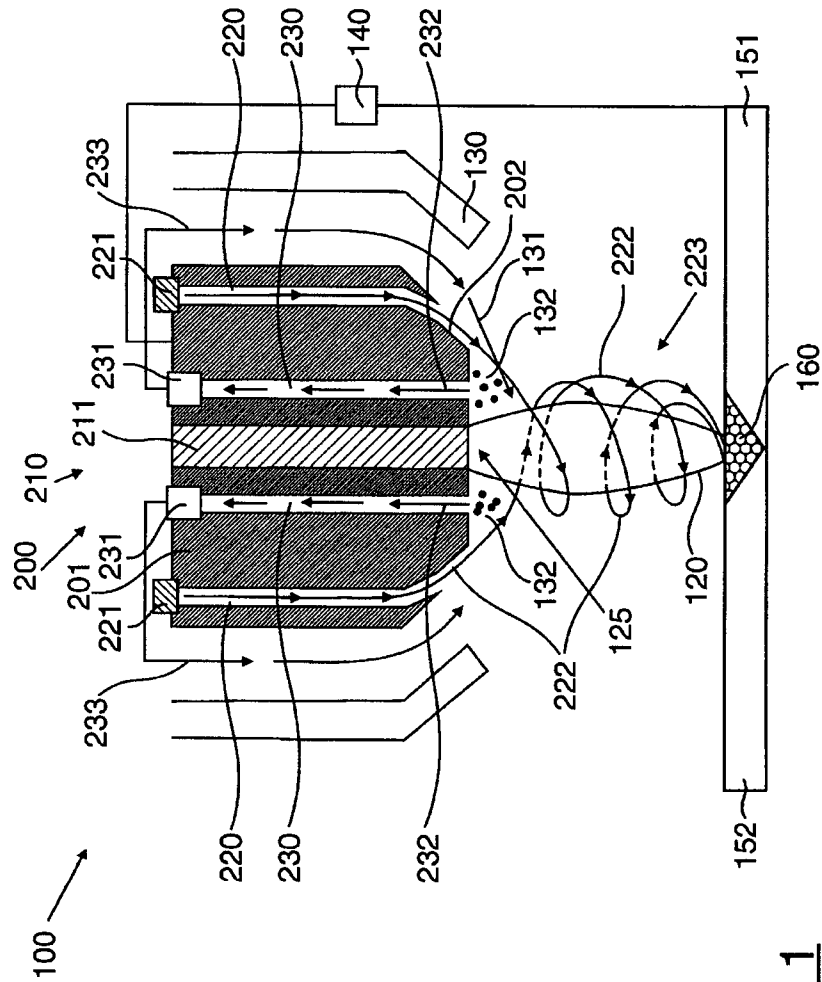


Fig. 1

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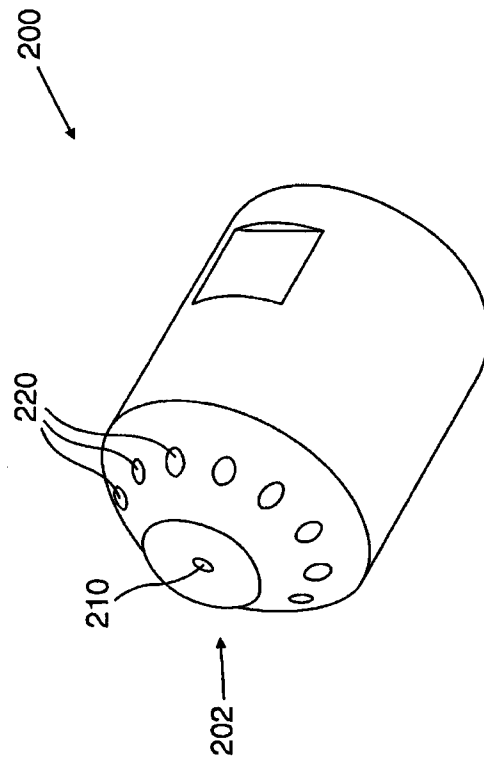


Fig. 2

