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Translation

The invention relates to a wire electrode for the spark-erosive cutting of non-conductive or poor-conductivity workpieces, and to a method for manufacturing the wire electrode.

In the spark-erosive cutting of conductive materials, use is made of the effect that, between the electrode and the material which is to be cut, a voltage potential is present which leads to sparkovers which are used to strip off the area of material which is to be cut. Such methods are known from the prior art.

Since, according to the normal principles of spark-erosive cutting, it is necessary to apply a potential to the workpiece, the basic principle causes problems with workpieces which are not electrically conductive.

DE-PS 26 37 432 describes a method and a device for splitting non-conductive or poor-conductivity workpieces, for example diamonds. Here, two wire electrodes guided parallel to each other are used, which have a plate-like structure, and the distance between which is selected such that a sparkover between the two electrodes takes place. The spark gap is arranged in such a way that the non-conductive or poor-conductivity material to be cut is eroded. This procedure has the decisive disadvantage that it is necessary to guide the two electrodes very precisely. This is particularly unfavourable in view of the fact that the electrodes are designed as wire electrodes and have to be constantly followed on with. A further disadvantage of this procedure is that there is only a very short erosion path available, since the sparkover takes place only between the two wire

electrodes. If, for reasons of design, a wider breadth of cut and/or a greater distance between the two electrodes is necessary, very high voltages have to be applied in order to achieve the desired effect.

A different solution to the underlying problem is disclosed for example by DE-PS 24 04 857 and consists in the forming of a surface-active substance in the dielectric solution by suitable preparation of the electrolyte solution; this substance leads to a certain conductivity of the respective surface area and is intended to cause a sparkover from the electrode to the non-conductive or poor-conductivity workpiece. This procedure requires considerable expenditure in the preparing and/or monitoring of the electrolyte solution and is therefore not suitable for many industrial uses.

The invention is based on the problem of creating a wire electrode arrangement for spark-erosive cutting, and a method for manufacturing the wire electrode, which, with simple structure and simple applicability, enables non-conductive materials to be cut by spark erosion.

As regards the wire electrode, the problem is solved in that the latter consists of at least one first and one second conductor wire extending substantially parallel to each other, the conductor wires being joined together and insulated from each other in such a way that they can be subjected to the impact of opposed electric voltages, so they form together a bipolar tool electrode.

The arrangement according to the invention is distinguished by a series of considerable advantages. Since according to the invention only one wire electrode is used which is formed on* the two individual

*There is probably a typing error in the German here, in which case "on" should read "from". - TRANSLATOR

electrodes, there is no need for extravagant guiding devices, so the wire electrode can be substantially used on known and commercially available spark-erosion machines which can be easily converted for this purpose. Further, there is according to the invention the considerable advantage that the distance between the two individual electrodes is pre-fixed and non-variable, so that the same conditions are always present during the cutting process. This is of special importance regarding in particular the cutting speed, and the electric potentials applied.

Further, it is of advantage according to the invention that the wire electrode can have any desired shape, thus making it possible to adapt exactly to the respective cutting conditions, for example the cutting speed and the cutting width.

The electrode arrangement according to the invention thus makes it possible to generate a sparkover between the two electrodes while preventing any short-circuit from occurring between the two electrodes; by means of this sparkover it is possible to cut the non-conductive or poor-conductivity material which is in the region of the cut.

An advantageous development of the invention provides that the wire electrode has a coiled structure. The coiling of the wire electrode has the advantage that particles are conveyed out of the cutting cleft, therefore non-contaminated dielectric can always continue to flow in the region where cutting is taking place. In particular in the case of very narrow machining clefts, this leads to a considerable increase in cutting speed and in quality of the cut. A further advantage of the coiling is that the sparkover region changes its positioning when the electrode moves longitudinally, and is rotated in the cleft of the cut relative to the

workpiece which is not moving. This ensures according to the invention that the cut is made uniformly over the whole cutting cleft. The quality of the cut is also considerably increased by this measure.

In order to enable the electric potential to be applied in accordance with purpose and requirements, the invention provides that the wire electrode is in electrical contact with the voltage source of the spark-erosion machine, via at least two sliding contacts insulated from each other. The sliding contacts are arranged in such a way that each of them is in contact with the respective electrode or electrodes which are subjected to the impact of the same potential. In the case of a non-coiled wire electrode, the association of the sliding contact with the electrode can be effected by appropriate directing and positioning of the electrode, whereas in the case of a coiled electrode a rotary mounting of the sliding contact may be preferred, in order to apply a positive potential to one sliding contact and a negative potential to the other, according to the invention.

The principle of the solution according to the invention enables the wire electrodes to be formed in many different ways. In a first embodiment, the first electrode is centrically arranged and has at least one side face on which the second electrode is arranged. The first electrode can be subjected to the impact of a positive potential, while the negative potential is applied to the second electrode. The wire electrode can be formed in such a way that the first centric electrode is not provided with an insulation, while the one or more second electrodes are insulated from the first electrode. The insulation of the second electrode is selected such that a direct short-circuit between the two electrodes is avoided and that the spark gap is formed by the dielectric in such a way that stripping of the

non-conductive or poor-conductivity materials takes place.

As an alternative to the above-described embodiment, it can be particularly advantageous if the wire electrode surrounds a centric insulator, on each of the outer faces of which are arranged the first and the second electrode respectively. The centric insulator can for example be formed by joining together two electrode wires provided with an insulation. It is however also possible to insulate only one of the electrode wires, while the other electrode wire is a bare wire. In this case it is necessary to join the two wires together in a suitable manner, for example by gluing.

In order to ensure, in particular in the case of a coiled wire electrode, that the sliding contacts firmly engage with the respective electrode regions, the invention provides that the respective wire electrodes are profiled for form-locking engagement with the sliding contact. The electrodes can for example have a prismatic cross-section, but it is also possible for them to be semicircular and to be provided with a longitudinal groove into which the sliding contact engages. The shape of the cross-sections of the wire electrodes can be selected such that the corresponding coiling can be taken into account, and in particular that rotary movement of the sliding contacts is guaranteed. The profiling of the wire electrode can be adapted to the forces which are to be transmitted to the sliding contact, thus possibly avoiding the necessity for an intrinsic drive for rotating the sliding contact, when a coiled wire electrode is used. In the same way, the profiling can be advantageous in the case of a non-coiled wire electrode.

As regards the method, the underlying problem is solved in that, in a first embodiment, a non-insulated wire, forming the first electrode, is profiled; in that, during the coiling of the profiled wire, the second electrode in

the form of an insulated wire is inserted into the coil, and in that regions of the insulating layer of the second electrode are removed by a scraper nozzle in a subsequent pass. Thus it is possible for example to use the insulated wire material in the form of a varnished wire made of copper, non-ferrous metal alloys, iron or steel or any other conductive material. The profiling of the electrode wire is done for example by rolling or drawing. It is also possible however, vice versa, to profile a varnished wire, forming a first electrode, by rolling or drawing, during which, with the use of known methods, the varnish layer is not damaged. During the coiling process, depending on the desired shape of the electrode, one or two additional bare non-insulated wires are also inserted into the coil. By means of the downstream-connected scraper nozzle, the varnish layer on the outer contact face or spark-discharge face of the first electrode is removed again, thus enabling a sparkover to take place between the individual electrodes. It is obvious that any desired quantity of individual wire electrodes can be selected both in this embodiment and in the other embodiments, in order to generate the desired spark gaps.

In a further preferred form of the method it is provided that several wires, at least one of which is insulated, are led through a coiling process, and that the insulating layer is removed, on the outer region of the wire electrodes, by means of a downstream-connected scraper nozzle. In this procedure, a centric insulator is formed which consists of the two insulating layers, laid against each other, of the individual insulated wires. It is particularly economic to use varnish wires made of normal copper wire or appropriate wire. The shaping of the downstream-connected scraper nozzle makes it possible to remove the insulation or varnish layer on certain target regions of the periphery of the wire electrode, in order to create the desired discharge

zones. In order to improve the engagement with the corresponding sliding electrode and to guide the wire electrode reliably, it can be advantageous for the wires to be profiled before or after the coiling. Thus it is possible for example to use segmented wires or half-round wires, or to provide the wire with a prismatic cross-section.

An alternative to the procedure just described is for the wires to be half-round wires, at least one of the wires being insulated and/or varnished. Here it may be advantageous to glue the two wires together, for example in a self-bonding process, the wires being heated at the same time.

In a variant of the method it can be advantageous if an insulated wire is coiled and subsequently a soft material with a low melting-point is inserted into the coiling. In this case too, a subsequent scraper nozzle can effect stripping of the respective outer face of the wire electrode. For example, the insulated wire can be a profiled wire with temperature-proof varnish, synthetic material, Teflon or non-conductive aluminium oxide. The metal inserted in the coil can for example be of lead, tin, zinc or corresponding alloys, or can be produced by a suitable applying process such as hot tin coating or hot galvanising or the like.

The invention thus creates the possibility of eroding non-conductive materials, in particular ceramic. It will be obvious to the person skilled in the art that the wire electrode according to the invention can be built up of two or more individual wire-shaped electrodes. It is further possible to form the wire electrode as a continuous electrode or a drain electrode.

The invention is described as follows with reference to

embodiments in conjunction with the drawing, which shows in

- Fig. 1 a schematic view of the spark-erosive cutting arrangement;
- Fig. 2 a schematic perspective view of a first embodiment of the arrangement according to the invention;
- Fig. 3 an enlarged view of the sliding contacts used in the arrangement according to Fig. 2;
- Fig. 4 a sectional view through an embodiment of the wire electrode according to the invention with a centric electrode;
- Fig. 5 a sectional view through an embodiment of the wire electrode according to the invention showing the sliding contacts, with a centric insulating body;
- Fig. 6 a sectional view of a further variant in the shaping of the wire electrode according to the invention.

Fig. 1 shows a schematic view of the spark-erosion arrangement according to the invention. This comprises a workpiece 7 of a non-conductive material, into which a cutting slit 8 is introduced. The whole arrangement is arranged in a normal way in a dielectric at least in the spark erosion region, as is known from the prior art. A wire electrode 3 is guided through the workpiece 7 and on to a wind-on spool from a supply spool, in a way not shown. Of the whole wire-guiding system, only deflector rollers 9 are shown in Fig. 1.

In the arrangement as in Fig. 1, sliding contacts 4, 5 are provided upstream and downstream respectively of the workpiece 7 and enable the wire electrode 3, which will be described below, to be connected to a positive potential or a negative potential. The sliding contacts 4 serve for connection to the positive potential, while the sliding contacts 5 serve to connect to the negative potential.

Fig. 2 shows an enlarged perspective view of a workpiece 7, partly in section, which is cut by means of the wire electrode 3. In the lower part of the picture, Fig. 2 shows a section through the shown embodiment of the wire electrode 3. The structure of the wire electrode will be described in detail below with reference to Fig. 4. The wire electrode comprises a first electrode 1 which is centrically arranged. Two second electrodes 2 are provided, one on each of the two flanks of the first electrode, and are insulated from the first electrode 1 by means of an insulating layer 10. The whole wire electrode 3 is provided with a substantially circular cross-section and is designed so that the insulating layer 10 of the second electrode 2 is at a distance at the outer peripheral region. This means that a spark gap can occur from the second electrode 2 to the bare non-insulated first electrode 1.

Fig. 3 shows the structure and arrangement of the wire electrode 3 on an enlarged scale.

The invention provides the possibility of using a different material for each of the first and the second electrode; these materials can be adapted to requirements in an optimal manner as regards their electrical properties, their resistance to wear and other values.

For transmitting the electric potential, in the

embodiment shown in Figs. 2 - 4 an annular sliding contact 4, 5 is provided for each wire electrode; it surrounds the wire electrode 3 and has inward-pointing arms 11 which are opposite each other, are adapted to the profiling of the wire electrode 3, and are so dimensioned that they are in engagement with the first or the second electrode 1, 2 respectively. The sliding contact 4 shown at the top of Fig. 3 serves for applying a positive potential, while the lower sliding contact 5 applies a negative potential. As indicated by the arrows in Fig. 2, the sliding contacts 4, 5 are in rotation, in order to maintain contact with the respective electrode 1 or 2 in the case of longitudinal movement of the coiled wire electrode 3. For adapting to the rotary movement of the sliding contact 4, 5, it is possible to profile the respective electrode or the sliding contact in order to guarantee transmission of force, as shown in the embodiments of Figs. 5 and 6.

Figs. 5 and 6 each show embodiments of the wire electrode according to the invention in which a centric insulator 6 is provided which electrically insulates the first electrode 1 from the second electrode 2. The two electrodes 1, 2 are each profiled, the electrode of the embodiment shown in Fig. 5 having a prismatic or triangular cross-section, while the electrode 1, 2 in the embodiment of Fig. 6 has a semicircular cross-section, into the peak of which a groove 12 is introduced. The groove 12 serves for form-locking engagement with a correspondingly profiled sliding contact (not shown). In the embodiment according to Fig. 5, a section view of the sliding contacts 4, 5 is shown; these are angular and surround the outer face of the electrode 1 or 2 respectively. It will be understood that the sliding contacts 4, 5 shown in Fig. 5 form only a part of the annular formation as shown in Fig. 3.

C L A I M S

1. A wire electrode (3) for the spark-erosive cutting of non-conductive or poor-conductivity workpieces, which electrode comprises at least one first and one second conductor wire (1, 2) extending substantially parallel to each other, the conductor wires (1, 2) being firmly joined together and insulated from each other in such a way that they can be subjected to the impact of opposed electric voltages, so they form together a bipolar tool electrode (3).
2. A wire electrode according to Claim 1, characterised in that the wire electrode (3) has a coiled structure.
3. A wire electrode according to either of Claims 1 and 2, characterised in that the first electrode (1) is centrically arranged and has side faces, on each of which is arranged one of the second electrodes (2).
4. A wire electrode according to either of Claims 1 and 2, characterised in that the wire electrode (3) surrounds a centric insulator (6), on each of the outer faces of which are arranged the first and the second electrode (1, 2) respectively.
5. A wire electrode according to Claim 4, characterised in that the first and the second electrode (1, 2) have a prismatic cross-section.
6. A wire electrode according to Claim 4, characterised in that the first and the second electrode (1, 2) have a semicircular cross-section.
7. A wire electrode according to Claim 5 or 6, characterised in that the first and the second electrode (1, 2) are profiled for positive-locking engagement with a sliding contact.



8. A method for manufacturing a wire electrode according to any one of Claims 1 - 3, during which a non-insulated wire forming the first electrode (1) is profiled, characterised in that, during the coiling of the profiled wire, the second electrode (2) in the form of an insulated wire is inserted into the coil, and in that regions of the insulating layer of the second electrode (2) are removed by a scraper nozzle in a subsequent pass.
9. A method for manufacturing a wire electrode according to any one of Claims 1 - 2 and 4 - 7, characterised in that several wires, at least one of which is insulated, are led through a coiling process, and in that the insulating layer is removed on the outer region of the wire electrode by means of a scraper nozzle connected downstream.
10. A method according to Claim 9, characterised in that the wires are profiled before or after the coiling.
11. A method according to Claim 9, characterised in that the wires are half-round wires.
12. A method according to any one of Claim 9 - 11, characterised in that the wires are glued together.
13. A method for manufacturing a wire electrode according to one of Claims 1 - 2, characterised in that an insulated wire is coiled; in that a second wire made of a soft material with a low melting-point is inserted into the coil, and in that outer face regions of the wire electrode are subsequently stripped by means of a scraper nozzle.

