

HIGH-STRENGTH EROSION ELECTRODE

Description:

5 The invention relates to a method for the manufacture of a wire electrode for the spark-erosion process and a wire electrode for this method, which consists of a core of steel, an intermediate layer of copper or a high copper-containing alloy, and an outer layer with at least 40 % zinc.

10 Wire electrodes, which are designed with multiple layers, which have a core of steel, an intermediate layer of copper arranged around the core, and an outer zinc-containing layer, are known, for example, from the DE-PS 29 06 245. All known wire electrodes, which are
15 constructed with a steel core, do indeed have an increased strength compared with copper or brass electrodes, however, all of these erosion electrodes have the disadvantage that if they have comparatively high strengths, their electrical conductivity is very low and
20 merely reaches $8 \text{ S}\cdot\text{m}/\text{mm}^2$. This comparatively high tensile strength is particularly advantageous for the cutting of high or thick workpieces or, however, also for the cutting of very small parts since high wire tensions are here demanded. However, these known wire electrodes
25 have the disadvantage that their erosion performance is relatively low. In particular, in the case of cutting very small parts with erosion-wire diameters of up to $10 \mu\text{m}$, high wire strengths are demanded in order to reduce deflection and vibration of the wire to a minimum.
30 Tungsten or molybdenum wires have been used up to now for the cutting of very small parts with wire thicknesses of $100 \mu\text{m}$ and less, however, tungsten or molybdenum wires are extremely expensive to manufacture. Erosion wires with a steel core and a brass outer layer have been
35 unable to be successful up to now for this purpose since they always, in comparison to tungsten wires, showed a lesser strength and a poorer erosion behaviour.

The basic purpose of the invention is to provide high-strength erosion electrodes with a core of steel of the abovementioned type and a method for their manufacture, which electrodes have strengths which are
5 1800 N/mm² and higher and, in addition, have a comparatively high conductivity of 10 S·m/mm² and more.

This purpose is attained with the characteristics of Claim 1 or of Claim 6.

Thus, an erosion wire of the invention has a steel
10 core K with a carbon content of 0.6 to 1 %, whereby a high copper-containing copper alloy is applied as an intermediate layer ZS onto said steel core. This intermediate layer is covered by an outer layer MS which, when the erosion wire is finished, consists of a zinc
15 alloy, the zinc content of which lies between 40 and 60 %. The condition for achieving the comparatively high conductivity of the erosion electrode with an equally high strength is that the core has a patented structure, consists advantageously of sorbite, whereby a further
20 layer is arranged between the outer layer and the core, which further layer contains high amounts of copper, that is, it is only low alloyed. Silver in the form of the alloy CuAg1 has here proven to be particularly advantageous as the alloy element. Also a copper alloy
25 with a small amount of zinc can be advantageously utilized for the intended purpose. An outer layer has been applied to this intermediate layer, which outer layer consists of a zinc alloy, in which the zinc content reaches at least 40 % and may reach a maximum of 60 %.

30 A wire electrode of the invention could be manufactured in such a manner that a sleeve out of a brass pipe or brass band is applied to a steel core enveloped with copper, and the composite is thereafter reduced by means of wire drawing. This type of
35 manufacture becomes more problematic the higher the zinc content in the outer layer is supposed to be. A further method could consist of providing a copper-enveloped

steel wire with a zinc-containing outer layer via a dipping method. The zinc content could here be adjusted at random. The difficulty with this method is to apply the outer layer with an even thickness over the circumference.

A very advantageous method for the manufacture of a wire electrode is that a steel core is enveloped with a copper layer, whereby the structure of the steel core should exist in a patented form. A zinc alloy is thereafter then applied to this copper intermediate layer, whereby in the simplest case the outer layer consists of pure zinc. This is followed by a diffusion annealing, the duration of which is chosen in dependency of the diffusion temperature such that the entire outer layer forms a zinc alloy, the zinc content of which amounts to 60 % at a maximum. The duration of the diffusion annealing is furthermore determined such that the demanded areas for the core wire, the intermediate layer and the outer layer adjust, whereby these areas of the three sections are not only important for the strength achieved in the final wire but also for its conductivity. A further decisive factor for the strength, however, also for the conductivity of the erosion wire is that in the final wire the core consists of a patented structure, whereby here electrical conductivity and strength are being equally optimized.

The wire, the core of which should already exist in the patented state is, after the diffusion annealing has occurred, reduced to its diameter by drawing.

The area of the core on the electrode should lie between 50 to 75 % of the entire electrode. The area of the intermediate layer should lie between 5 and 40 % and the area of the outer layer between 10 to 30 %. If one furthermore meets the demand that the zinc content of the outer layer lies between 40 and 60, advantageously at slightly above 50 %, then one obtains an electrode with a conductivity which lies between 10 and 18 S·m/mm²,

whereby at the same time strengths are obtained which lie between 1800 and 2500 N/mm². It must hereby be noted that the demand for high conductivity and high strength is contrare, namely an inventive wire with a very high strength has a comparatively low electrical conductivity and vice versa. The wires of the invention can be drawn to a diameter of below 10 μ m, namely, to diameters which are sufficiently small for the up to now known uses. It has thereby been found to be particularly advantageous that these wires with a thin diameter can easily replace the up to now used tungsten and molybdenum wires and are by comparison significantly less expensive to manufacture, show no aging, have lower raw-material costs, and moreover offer a higher safety in manufacture and have constant erosion characteristics. The achieved quality in manufacture is so great that the wire of the invention will practically not break down on the erosion machine, whereas the breakdown of the up to now utilized molybdenum or tungsten wire amounts to up to 50 %.

20 The high strength is particularly advantageous in the case of erosion wires with diameters of above 100 μ m when workpieces with a greater height are to be cut since high wire tensions are required here in order to keep bending and vibrations low.

25 An electrode of the invention is distinguished by a high conductivity and a comparatively high strength. Moreover, the cutting quality with a high exactness in contours is very good, whereby this precision is favored by the high wire tension based on the high strength of

30 the wire.

Claims:

1. A method for the manufacture of a high-strength erosion electrode comprising a core of steel, an intermediate layer of copper or a high copper-containing alloy, and an outer layer of an alloy containing at least 40 % zinc, characterized in that a steel with a carbon content of 0.6 to 1 wt.% is used as the core, onto which is applied the intermediate layer of copper or a high copper-containing alloy, that an outer layer of zinc or a high zinc-containing alloy is applied onto the intermediate layer, that the wire, prior to a first intermediate annealing, is subjected to a diffusion annealing such that on the one hand the outer layer forms an alloy with a zinc content, the melting point of which is higher than the austenitization temperature required for the patenting of the steel core, and on the other hand the diffusion process is carried out so long that, taking into consideration one or rather several following patentings of the erosion wire, the outer layer maintains the desired composition and strength, whereby the erosion electrode is patented during each intermediate annealing.

2. The method according to Claim 1, characterized in that a patented steel wire, which is provided with a copper intermediate layer, is utilized as the initial wire, that a high zinc-containing outer layer is applied to the intermediate layer, that the wire is subsequently subjected to a diffusion annealing such that a brass outer layer with a predetermined composition and strength results, and that the erosion electrode is patented after each deformation stage prior to reaching its final diameter.

3. The method according to Claim 1 or 2, characterized in that the outer layer after the first diffusion annealing has a zinc content, which does not exceed 60 %.



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REPLACED**

4. The method according to one of the Claims 2 or 3, characterized in that the initial wire has a core diameter of 0.8 mm and a layer thickness of the intermediate layer of 0.1 mm, that the outer layer applied onto the
5 intermediate layer is 30 μm , that the wire is then subjected to a diffusion annealing at 4000C over 4 hours, and is thereafter drawn to a diameter of approximately 0.4 mm, that the erosion wire is thereafter patented and is then drawn under, if necessary, further patentings to its
10 final diameter.

5. An erosion electrode with a core of steel, an intermediate layer of copper or a high copper-containing alloy and an outer layer with at least 40 % zinc,
15 characterized in that the steel core has a patented structure with a carbon content of 0.6 to 1 wt.%, which occupies an area of the core of 50 to 75 % of the diameter of the erosion electrode, that the intermediate layer has an area of 5 to 40 % and the outer layer has an area of 10
20 to 30 %, and that the zinc content of the outer layer lies between 40 and 60 wt.%.

6. The erosion electrode according to Claim 5, characterized in that the conductivity of the erosion
25 electrode is at least 10 preferably larger than 12 $\text{S}\cdot\text{m}/\text{mm}^2$.

7. The erosion electrode according to Claim 5 or 6, characterized in that the intermediate layer consists of
30 copper with a small amount of silver.

8. The erosion electrode according to Claim 7, characterized in that the intermediate layer consists of CuAg1.



9. The erosion electrode according to one of the Claims 5 to 8, characterized in that the strength of the erosion wire is at least 1800 N/mm², advantageously at least 200 N/mm².

