

The present invention concerns, according to a first aspect, a rod for welding with an external source of calorific energy such as a chemical or plasma flame of the type mentioned in the precharacterising clause of Claim 1. A rod of this type is known from a prior use illustrated in the leaflet "Technodur" of the Technogénia company, dated June 1982. For example, the energy source may be an oxyacetylene torch, a TIG process, a so-called atomic hydrogen torch, or other variants operating by ionisation of a gas.

Patent US-A-2 219 462 describes two examples of welding products, which generally take the form of rigid rods, a few tens of centimetres long.

In the first example, the rods have a metal core covered with a coating containing the principal welding components in powder form, bound together and to the metal core by siliceous binders.

In the second example, composite rods consist of metal tubes filled with a supply element of a different composition containing, for example, tungsten carbides. Rods of this type are also rigid, and of a limited length.

Document FR-A-1 003 435 describes a method for manufacturing a rigid electrode comprising a core wire covered with a coating comprising the principal welding components in powder form, bound together and to the metal core by siliceous binders.

The fact that the rods are discontinuous significantly reduces the productivity of manual welding operations requiring the use of large quantities of product, such as for example the operation of hardfacing the surfaces of sizable parts. Indeed, for each rod, the operator is forced to abandon a scrap at the end in order not to burn himself, or else he has to butt the scrap together with the end of the next rod, a tedious operation which can prove difficult.

The particular aim of the present invention is to avoid the disadvantages of known methods and devices, by proposing means making it possible to improve significantly the productivity of welding or resurfacing operations. In particular, the invention means that a very long welding product can be produced, with a coated metal core, known as a continuous rod, for example several tens of metres long, sufficiently flexible to be produced as a coil, and be wound and unwound, and whose principal welding components are contained in the coating.

The present invention provides substantial advantages over known products in which the principal welding components are contained either inside a metal tube or in a coating surrounding a metal core. Indeed, these products are very inflexible, such that they cannot be wound or unwound to form a coil of reasonable dimensions, sufficiently small to facilitate handling.

The continuous rod according to the invention is very flexible in comparison with known products, particularly products with a metal core coated with the principal welding components, the said products being short and rigid.

In the field of arc welding or brazing, relatively flexible welding products with a coated metal core are known. This is true of the products described in documents GB-A-1 007 039 and US-A-2 107 434. However, in these known products, the principal welding components consist of the actual metal core of the rod; the coating contains secondary elements, that is, either brazing flux, or products intended to create a gaseous protective covering during arc welding. The core is relatively thick, whilst the coating is relatively thin, such that it is fairly easy to obtain relatively great flexibility. The composition constituting the coating of these known products, in their final state, does not allow for the production of a thick, flexible coating containing the principal welding components. Indeed, in their final state, these products contain neither binder nor plasticiser.

Document DE-C-874 888 describes a continuous welding electrode obtained by extruding a coating around a metal core wire heated by electrical conduction or by induction. There is no indication of the composition of the coating.

One of the main difficulties for achieving sufficient flexibility to allow production as a coil, resides in the fact that the principal welding components are contained in the coating. In fact, the continuous rod has to consist of a relatively thin metal core and a relatively thick coating. In spite of its thickness, the coating must be flexible and strong.

Users are familiar with rigid and relatively resistant rods with a coated metal core. Thus, the invention also has the aim of producing flexible rods with a coated metal core which can be handled and transported without any particular precautions, that is, in which no significant, troublesome break is observed in the coating or the whole

product in normal conditions of handling and use. For it is important for the coating not to be broken, since that would lead to uneven, poor-quality welding.

It is also important to avoid the unfortunate - from the welding point of view - influence of the metal wire forming the rod's core. For the metal wire generally melts at a higher temperature than the coating. In the invention, means are sought to reduce the diameter of this wire and thus accelerate its melting.

However, in seeking to reduce the diameter of the wire, one runs into the problem of guiding it during manufacture of the rod. Guiding the core inside the machine has to taken place without buckling or jamming. The invention aims to solve this problem by providing means to allow a very thin core to pass through a machine for coating electrodes, a machine well known in the art, used for producing welding products. In particular, it is necessary to provide an even supply of metal wire in the machine. Such an even supply is easier to produce in the case of continuous rods, preferably wound into coils.

It has to be possible to manufacture the continuous rod by extruding the coating around the core wire, a process which is *a priori* appropriate for very long products. For this purpose, the coating has to contain a type of binder whose specific characteristics permit manufacture by extrusion.

At the same time, the rod has to ensure correct welding and, in particular, the welding components bound by the binder must not be "blown" by the flame, but must come together properly in a molten drop ensuring correct mixing before being deposited on the part to be welded.

The invention also aims to allow the use of binders whose decomposition during welding gives off only inoffensive products, for example water and carbon dioxide. Working conditions are thus considerably improved.

In order to achieve these aims, the invention provides for a welding rod as defined in Claim 1.

In the case of continuous rods for anti-abrasion resurfacing, the principal welding components preferably comprise tungsten carbide particles, and particles of an alloy whose melting point is lower than that of tungsten carbide. The alloy may with advantage contain chromium, silicon, boron and nickel.

The term "element with a plasticising effect" denotes any substance making the coating smooth and homogeneous, and conferring on it a flexibility which will make it possible to produce the rod in the form of a coil of such a dimension as to be easy to handle manually, for example with a diameter of a few tens of centimetres. Such a result is obtained, for example, by using a water or solvent-miscible liquid, and by having a very low vapour tension at ambient temperature. Examples of this type of liquid are glycerine or glycol. When used with a binder mixed with water or solvent, heating at a sufficient temperature after extrusion results in the removal of the water or solvent, but the plasticiser remains and makes the organic binder very flexible.

The organic binder is with advantage a powder which, when it absorbs a solvent, takes on a form which binds the particles of principal welding components, so that the mixture can be extruded. The solvent used must not evaporate too rapidly in normal temperature conditions, but must on the contrary remain in the binder, until extracted by heating, after extrusion is complete.

In its final state, the continuous rod according to the invention contains the binder and the plasticiser. Their simultaneous presence makes it possible to obtain the required qualities in the rod. Heating after extrusion must completely, or almost completely, remove the solvent but should not eliminate or adulterate the binder and the plasticiser.

According to another characteristic, the organic binder comprises at least one of the following components: hydroxyethylmethyl cellulose, galactomanose, or carboxymethyl cellulose. The best results have been obtained with hydroxyethylmethyl cellulose, a binder which clearly provides the best compromise between the main qualities sought for the rod: sufficient flexibility for coiling, sufficient strength to avoid the appearance of breaks in the coating, and sufficient proximity of the welding components to avoid the occurrence of blowing. The use of hydroxyethylmethyl cellulose as a binder for principal welding component powders seems a characteristic not obvious to the person skilled in the art. Indeed, the rigid welding rods normally used, for example the rods described in patent US 2 219 462, always include a binder with a sodium or potassium silicate base. Now, the presence of a siliceous binder is incompatible with the presence of hydroxyethylmethyl cellulose when making a weld, and a good result could not be expected within the context of the present invention.

According to another characteristic of the invention, the plasticising effect of a binder absorbing water is obtained by a water-soluble liquid having low surface tension at ambient temperature. Glycerine, glycol and triethanolamine have been used successfully.

According to the invention, and at the same time as the compositions making it possible to obtain a flexible coating, a noticeable improvement in flexibility is noted by using in the coating a certain proportion of alloy particles with a spheroidal form. In the following description and in the claims, the term spheroidal particle denotes a rounded particle with no angles or sharp ridges. Good results are obtained by using particles produced by pulverising.

The particles of spheroidal form should represent at least 30% by volume of all the welding products. If this condition is not fulfilled, it is difficult to obtain a truly flexible coating. Efforts may be made to produce flexible coatings with non-spheroidal alloy particles. For this, it is sufficient to increase the proportion of organic binders. But it is then observed that welding is no longer possible. In fact, the particles become blown before having had time to agglomerate and melt together.

Thus, the organic binder must be present in the coating in a sufficiently large proportion to permit extrusion and to contribute to the rod's mechanical properties, but this proportion must however be small enough to avoid the occurrence of blowing phenomena. A proportion of between 0.5 and 1.5% by weight in relation to the whole coating is necessary.

It is preferable to use an organic binder of a type capable of absorbing at least five times its weight of water whilst swelling. In this way, extrusion is facilitated and, after drying, removal of the binder encourages the particles of welding products to come together, improving the quality of welding.

According to another characteristic of the invention, the metal core wire is produced using an elastic metal. A semi-hardened nickel has been used successfully. Thus, when mechanical stresses are applied to the rod, the elasticity of the core wire distributes deformations over a relatively great length of rod, avoiding the appearance of kinks which would lead to breaks in the coating.

Document DE-C-874 888 describes a method and device for manufacturing a welding electrode, in which a coating is extruded over a metal core wire. It appears

however that such a device and method are not applicable in the case of a rod such as that of the present invention, comprising a thick coating over a thin core wire and, in particular, does not solve the problem of guiding the core wire during manufacture of the rod. Thus, according to another aspect of the invention, a rod is produced by the succession of steps defined in Claim 8:

Other aims, characteristics and advantages of the present invention will be apparent from the following description of particular embodiments, given in relation to the attached figures, amongst which:

- Figure 1 represents a rod according to the invention, wound into a coil;
- Figure 2 represents a transverse sectional view of a rod according to the invention; and
- Figure 3 represents diagrammatically a device for manufacturing the rod according to the invention.

As represented in Figure 1, the continuous welding rod 1 according to the invention is flexible along its length and can be wound over itself, or around a reel, in the form of a coil. In normal welding conditions, sufficient flexibility can be provided to give the rod a coil shape whose diameter is a few tens of centimetres.

Figure 2 shows a transverse sectional view in a larger scale of the rod according to the invention. The rod comprises a metal core 2, cylindrical in form, covered with a coating 3 also cylindrical in form. In the coating 3, which contains the principal welding components, spheroidal particles 4 of welding products - for example, alloy particles - have been shown. Molten tungsten carbide particles 5 are shown with sharp ridges. In practice, most tungsten carbide particles have sharp ridges, since it is very difficult to obtain such particles with rounded edges. Particles 4 and 5 are embedded in an excipient 6 of binder and plasticiser. In the coating, the particles of principal welding components, the binder and the plasticiser form a generally homogeneous structure.

One may with advantage choose particles of welding products whose grain size is, for the most part, between 5 millimetres and 0.04 millimetres. The applicant has found that, if most of the tungsten carbide particles are smaller than 0.04 mm, the resurfacing layer obtained using the continuous rod is not satisfactory. This is

probably due to the fact that when the particles are too small, their effective surface encourages chemical reactions during welding, these reactions making the nickel-based alloy fragile. It is noted furthermore that tungsten carbide particles which are too small become agglomerated, leading to the presence in the resurfacing layer of a small number of large tungsten carbide particles. The effective concentration of tungsten carbide is then diminished, and resistance to abrasion is lowered. In practice, it is recommended that tungsten carbide particles whose size is less than 0.04 mm should not represent more than 20% by weight of the total quantity of tungsten carbide.

The presence of particles which are too large, for example, more than 5 mm, makes extrusion difficult or defective.

The metal core wire 2 should preferably have diameter of less than 1.5 mm. The rod may have an outside diameter of 5 to 10 millimetres. Thus, it may be seen that the metal core wire occupies relatively very little volume in comparison with the coating, such that the product has the maximum amount of active elements.

It is important that most of the volume of the continuous rod according to the invention be occupied by the principal welding components, that is, by products intended to constitute the layer of weld or anti-abrasion resurfacing on a surface, and not by products which melt at a temperature greater than the melting point of the alloy powder mixed with the tungsten carbide powder. The metal core 2 is only a framework on which the principal welding components can be assembled.

An example of the method for producing continuous rods is given below. In this example, the method comprises the following steps:

- a) mixing the principal welding components in powder form with at least one organic binder, at least one solvent of the binder being capable of elimination by evaporation, and at least one element with a plasticising effect;
- b) extruding the composition around a continuous metal core wire so as to form a continuous rod;
- c) removing the solvent by suitable heating. Heating takes place at a temperature below the limiting temperature which would cause the decomposition of the binder and/or the plasticiser.

A composition of the mixture, allowing the production of a rod to be used, for example, for resurfacing with petroleum drilling stabilisers, is as follows:

- melted tungsten carbide: 60 to 68%;
- pulverised alloy comprising 1.5% silicon, 1.5% boron, 7% chromium, and the rest nickel; the alloy represents 32 to 40% of the total;
- hydroxyethylmethyl cellulose: 0.5 to 1.5%;
- water, in a quantity to be adjusted according to the extrusion and the welding quality: 2 to 10%;
- glycerine: 0.2 to 1%;

the total having to equal 100%.

In the above example, the melting point of the alloy is around 1000°C. In contrast, tungsten carbide has a melting point of around 2750°C, whilst the core wire 2 melts at around 1350°C. Thus, in normal welding conditions, the tungsten carbide is not melted, but is deposited in solid form on the surface to be resurfaced, its particles being carried by the alloy. It is preferable to use an alloy whose melting point is lower than 1100°C.

A machine 7 for coating the electrodes is used to implement the method for producing the rods, this machine being well known in the art. For example, a machine sold by OERLIKON under a reference such as EP 12 is suitable for this process. This machine 7 comprises an extruding press 8, means 9 for entraining a core wire through the press and through the extrusion die 10, and means 11 for pushing the components 15 of the coating through the die 10.

According to the invention, a device is fitted to the inlet of the machine for unwinding and continuously feeding in a core wire 2 wound into an input coil 12, and a device is fitted to the outlet of the machine for continuously winding up the coated rod 1. The coated rod 1 can be wound into an output coil 13. The output coil 13 is preferably entrained by rotation, by entrainment means 14 for drawing the wire out of the extruder and stretching it while it goes through the die at a predetermined

tension. In this way, a wire can be entrained correctly even when it is of small diameter, that is, less than 1.5 millimetres.

As a function of the diameter of the coated rod and the type of material constituting the coating, a choice can be made particularly between two means of traction for the rod leaving the extruder: according to a first method, the entrainment means 14 impart a sufficient constant torque to the output coil 13 to stretch the coated rod 1 between the coil 13 and die 10; according to a second method, the entrainment means 14 impart a sufficient constant torque to the output coil 13, but the coated rod forms, by gravity, a hanging half-loop 100 of the chosen dimension between the coil 13 and the die 10, which imparts a sufficient constant torque to the wire leaving the extruder. In both cases, the speed of advance is fixed by the entrainment means 9 for the core wire.

The present invention includes the various variants and generalisations contained within the scope of the following claims. In particular, it is possible to use other organic binders and other plasticisers without leaving the scope of the invention. The nickel-based alloy can be different. Different solvents can be mixed with the organic binder. The thickness, shape and constitution of the metal core can be modified. Particles of hard material other than tungsten carbide, with a high melting point, can also be used. And one may freely choose the length of the rods, and for example manufacture rods several metres long wound into coils, or rods a few centimetres long with the same internal structure according to the invention.

CLAIMS

1. A welding rod using an external source of energy, the said rod being constituted of a thin metal core (2) covered with a thick coating (3) having the principal welding components (4, 5) in powder form, comprising tungsten carbide particles and particles of an alloy whose melting point is lower than that of tungsten carbide, the particles being bound together and to the core by an excipient (6) acting as a binder and containing at least one organic binder of a type having the property of absorbing a solvent and of restoring it by evaporation, the rod being sufficiently flexible to enable it to be produced in the form of a continuous, very long rod wound into a coil which can be handled manually, characterised in that the proportion of binder in the coating (3) is small enough to avoid the occurrence of blowing phenomena, the excipient contains at least one element with a plasticising effect, the particles, the organic binder and the plasticiser form a generally homogeneous structure, the welding components comprise particles of spheroidal form representing more than 30% by volume of the welding components of the coating, the organic binder is present in the coating in a proportion of between 0.5 and 1.5% by weight.
2. A rod according to Claim 1, characterised in that the organic binder comprises at least one of the following components
 - hydroxyethylmethyl cellulose,
 - galactomanose,
 - carboxymethyl cellulose.
3. A rod according to one of Claims 1 or 2, characterised in that the element with a plasticising effect is a water-soluble liquid having low surface tension at ambient temperature, such as glycerine, glycol or triethanolamine.
4. A rod according to any of Claims 1 to 3, characterised in that the organic binder is of a type capable of absorbing at least five times its weight of water whilst swelling.
5. A rod according to any of Claims 1 to 4, characterised in that the coating contains a proportion by weight of 0.5 to 1.5% hydroxyethylmethyl cellulose, and 0.2 to 1% glycerine.

6. A rod according to any of Claims 1 to 5, characterised in that the core wire (2) is elastic, so as to distribute the normal deformations over a relatively great length of rod and to avoid kinks and breaks in the coating.
7. A rod according to any of Claims 1 to 6, characterised in that the principal welding components comprise a plurality of tungsten carbide particles and a plurality of particles of a nickel-based alloy, at most 20% of the tungsten carbide particles having a grain size of less than 0.04 mm.
8. A method for producing rods according to any of Claims 1 to 7, comprising the following steps:
 - a) mixing the principal welding components in powder form with at least one organic binder of a type exhibiting the property of absorbing a solvent and restoring it by evaporation, at least one solvent of the binder being capable of elimination by evaporation, and at least one element having a plasticising effect, the main welding components comprising tungsten carbide particles and particles of an alloy whose melting point is lower than that of tungsten carbide, the proportion of binder in the coating being small enough to avoid the occurrence of blowing phenomena, the welding components comprising particles of spheroidal form representing more than 30% by volume of the welding components of the coating, the organic binder being present in the coating in a proportion of between 0.5 and 1.5% by weight,
 - b) extruding the composition around a continuous metal core wire (2), the particles, the organic binder and the plasticiser forming a generally homogeneous structure,
 - c) drawing the core wire (2) leaving the extruder (7) in such a way that the coated rod (1) forms, by gravity, a hanging 30 half-loop (100) between the die (10) and an output coil (13) into which the coated rod (1) is wound, or drawing the core wire (2) leaving the extruder (7) by entrainment means (14) which impart to the output coil (13) a sufficient constant torque to stretch the coated rod (1) between the coil (13) and the die (10),

- d) removing the solvent by heating, this heating taking place at a temperature below the limiting temperature which would cause the decomposition of the binder or the plasticiser.