LIQUID PHASE MODIFICATION METHODS THROUGH NANOPOWDER INJECTION IN TIG AND IMPULSE TIG WELDING METHODS

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Summary: *In practice there are several known methods of inserting the nanopowder to the welding layer, they are specified according the conditions needed for the welding process. This article examines some new and innovative opportunities of liquid phase modification through insertion of nano-sized particles without being melted, according to TIG and Impulse TIG overlay welding methods.*

Keywords: Nanopowder, TIG, Impulse TIG, Overlay Welding

1. Introduction

Overlay welding is a technology where a layer of metal alloy is being laid on the work piece. The overlay welding with different kinds of metal with specific chemical and mechanical properties performed on the working surfaces of the parts, increases their durability and reduce the weariness [6].

The area of operation of the overlay welded surfaces are defined by the chemical composition of the layer. The alloy is being produced by melding the main metal and by adding other metal, powder or flux. Main principles to evaluate the alloy are: homogeneousness of the composition in the welded volume, cost effectiveness, application capability of the alloying method and other. To insert alloy elements in to the base metal, following methods are being used[4]:

- Use of solid electrode wires or tapes – traditional method of becoming an alloy with particular chemical composition in wide scope of welding conditions where the alloying elements are well distributed in the volume.
- Alloying with use of electrodes – the most widely spread method. The overlay metal is homogeneous by composition, well formed, lack of pores and slag and also the chemical composition is fully based on the electrode.
- Another method of overlay welding uses low carbon wires or tapes and ceramic flux or flux mixtures, from which the alloying elements are being transferred to the overlay metal. In this method the flux is the main source of alloying and the more the volume of the melted flux the bigger is the quantity of the elements inserted in to the overlay metal. That is why the composition of the metal is dependent of the welding regime, the mass and composition of the used flux.
- Alloying using pastes which are being deposited on the welded layer and then melted with or without additional low carbon wire. The chemical composition of the welded metal is determined by the quantity of the paste and also by the quantity of the melted alloying material. (Fig.1).
- The alloying of the surface layers with carbide powders, nitrides, oxides, etc. whitch have the size of nano paricles could be observed as another innovative method (nano particles have the size 1.10^{-9}m). By melting thise powders, the alloying is similar to the method with the pastes (Fig.1). On the other hand, if the nano particles are inserted in the lower temperature area of the weld seam without being melted, they will take places in the crystal lattice of the melted metal and will make the structure refined, which will lead to better mechanical properties of the overlay layer (Fig.2). The new metal will be then a composite material, obtained by matrix consistent of construction steel and particles of nitrides, carbides and other which contains the welding powder [2].

The innovation of the method lie on the fact that the powder maintain it's state, it is not being meltd and so the liquid phase is being modified [5].

Because of the low power of the arc, the use of TIG and impulse TIG welding preocesses is not very efficient compared to the plasma powder welding method. On the other hand it could be used to weld smaller parts (blades, wear resistant plates, etc), where a smaller amount of heating is requiered, so that the deformations could be avoided.

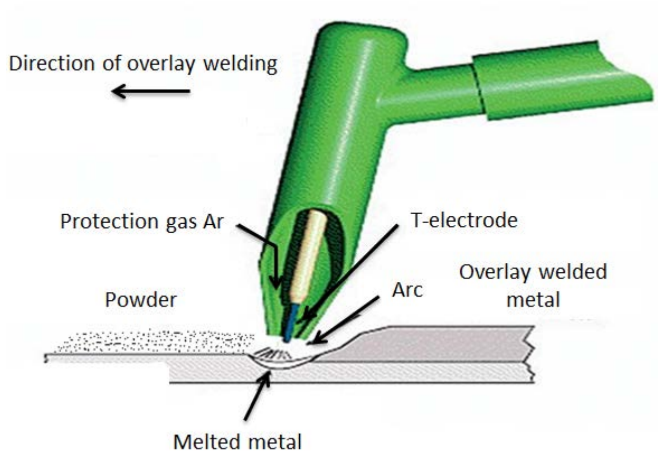

Fig. 1. *Welding with melting of powder*

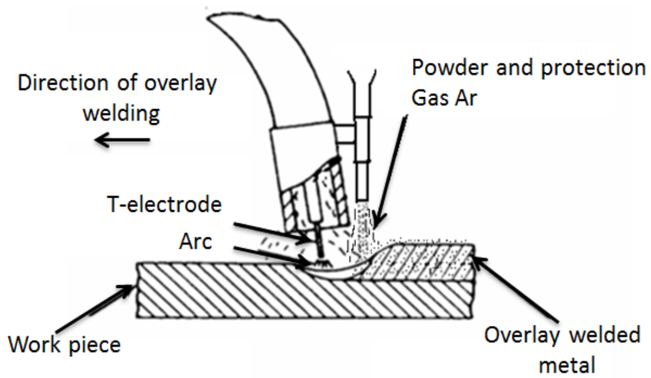

Fig. 2. *Welding without melting of powder*

2. Methods for modification of the liquid phase using nano-powders without melting them.

Several variants of welding without melting the nano-powders has been explored. These methods as well as some of their features will be observed in short.

A) The powders could be inserted at the end of the weldseam using proper additional device mechanism (Fig 3). It points 35º- 45º in relation to the direction of welding, it has the shape of bended wire 2mm in diameter and at the one end it has the contour of the weldseam (elliptical). The devise is being attached and "towed" by the gas nozzle. A few millimeters parallel to the welding line there is the powder trail which is being pulled in by the device to the weldseam. The powder trail is laid on the work piece in safety distance from the heat so that it could not be melted. It is 2-3mm wide and 2mm high. By the movement of the nozzle the powder is being pulled to the end of the weldseam. The powder is additionally pushed from the additional device so that it can penetrate better in to the seam.

TIG overly welding is flexible because of the manual movement of the nozzle, the arc is very powerful in gas environment and there is no need of additional materials in case of welding thin sheet metal layers. These characteristics make the method universal. Other advantages of the process are: inert-gas protection and T-electrode have no effect on the chemical composition of the metal; there is no slag and splashes; the arc is being observed; fine adjustment of the welding regime is possible; mechanizing and automation is also possible; nano-particles could be inserted in different temperature zones of the weldseam. With the time the bended wire bends because of the heat, deforms and it could not push the nano-powder proper any more to the melted metal.

B) Fig. 4 shows an innovative method for insertion of nano-powders with or without melting. The devise is designed to deliver a mixture of inter gas and powder. It ensures a control over the amount of powder being used for the welding. The inert gas goes in through inlet 1, then enters the injector 3 and creates vacuum in channel 7. This leads to sucking the particles out from the reservoir 5. The control over the amount of the powder that has been sucked out is ensured through the valve 6. Inlet 2 is also supplied with inert gas so that air can't get to the mixture and from there to the weldseam. That way the particles that enter the weldseam make its structure refined.

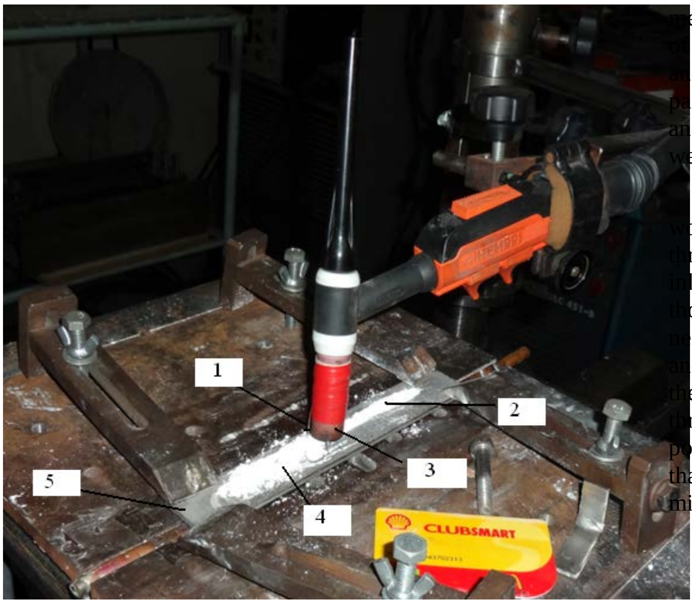

Fig.3. *TIG and impulse TIG welding without melting the nano-powder.*
1 – wire, with weldseam contour bend; 2 – powder on the side; 3 – nozzle ; 4 – powder after welding ; 5 – work piece.

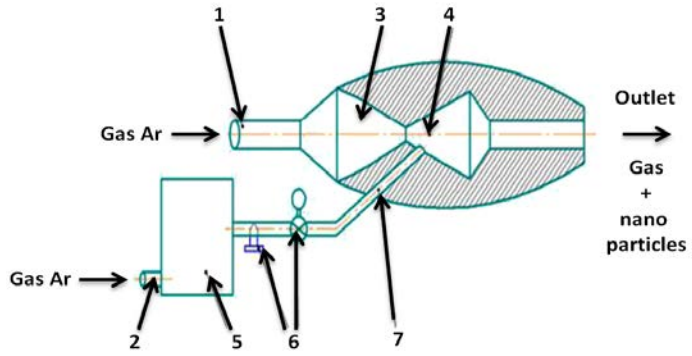

Fig. 4. *Principle view of device for nano-powder insertion with or without melting.*
1,2 – intert gas insertion nipples; 3 – injector; 4 - mixture chamber; 5 – powder reservoir ; 6 – valve for controling the amount of powder ; 7 – channel

Fig. 5. *Insertion of nano-powders behind the weldseam in the low temperature area 1 – nozzle; 2 – insertion tube for nano-powder and inert gas; 3 – nano-powder reservoir; 4 – inlet for the protection gas argon; 5 – heated metal right after the arc goes out; 6 – work piece.*

Fig.5 shows the insertion of nano particles in to the melted metal direct after the arc, in the area of lower temperature. The end of the device 5 is positioned in an angle according to the nozzle 1 and the melted metal 5. The inert gas goes in through inlet 4 and passes through the nano-powder reservoir which is being sucked out and transported behind the welding arc. The direction of overlay welding is from right to left.

Fig.6 shows another way of insertion of nano-powders. The working principle is shown on Fig.4. The inert gas is being fed through the reservoir 3, the transport gas correspondingly through inlet 5. In the body 4 there is a needle which is being pushed back thought the button 7. After releasing the button a spring pushes the needle back to the initial position. That way the needle goes back and forward and prevents the blocking of the hole which delivers the powder after the arc. The pressure of the inert gas that goes through the reservoir is in this case of most importance. It is possible that at high pressure the powder could be squeezed in and that could lead to blocking the hole of the reservoir from which the mixture of powder and inert gas should go out.

Fig. 6 *Insertion of nano-powder behind the arc of welding in the low temperature area.*
1 – nozzle; 2 –device outlet; 3 – nano-powder reservoir; 4 – body of the device; 5 – inert gas inlet; 6 – work piece.

4. Conclusions

1. There have been made experiments with all methods for insertion of nano-powders behind the welding arc in to the low temperature area.

2. Best result was produced with the method described on Fig.5 where the protection and transport gases are being fed from the same source.

3. The results are shown on Fig.7. It shows the overlay welding of one, two on ½ from the width overlapping or tree also overlapping lines. There are no visible defects, the lines are consistent and well formed.

4. That gives us reason to continue the research of these methods for insertion of nano-powders in the area behind the welding arc.

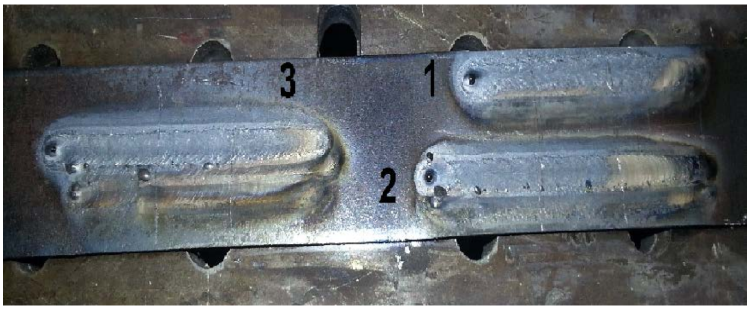

Fig. 7 *Overlay welded lines. 1 – one line ; 2 – two overlapping lines; 3 – tree lines*

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