

INVESTIGATION OF TIG-WELDING PLASMA AND THE ELECTRODE CONTAMINATION

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ABSTRACT

TIG welding experiments have been used for the welded joints of the austenitic stainless steel and molybdenum. The aim of the experiments was to find the optimal welding parameters. The problems that occurred throughout the welding process were due to the very high melting point of the Mo. Also, using optical microscopy and scanning electron microscopy have performed a proper testing in parallel with the experiments. Regarding to the wear of electrode, there have been determined the tip angle, the tapering and the effect of the electrode's material composition. The latter parameter was investigated for thorium-oxide and lanthanum-oxide alloyed electrodes

KEYWORDS

TIG welding, tungsten electrode, arc ignition

1 INTRODUCTION

It often happens during the production of lamps that thin wires or sheets of different material quality have to be welded together. Among the arc welding procedures the microplasma welding and the micro-TIG welding is considered the most important technique, and it has to be stated that in both techniques the W-electrode plays a key role [1].

On one hand, the formation of the W-electrode's tips, concretely the tip angle and the tapering, through the size of anode spot influences the weld penetration [2]. Consequently, the more pointed the electrode, the smaller the penetration. On the other hand, the electrode's material, more precisely the one alloyed for the W-electrode, of small ionisation potential type determines the dynamical arc ignition characteristic and influences the tapering's character, that can be especially significant considering the conditions of arc spot welding

2 EXPERIMENTS

During the welding experiments there have been used materials paired in two different ways. In the first case, a 0.4 mm molybdenum wire had to be welded into the eyelet of a 0.35 mm thick AISI 304 type austenitic stainless steel sheet. In the second combination, instead of Mo a Ni-Mn alloy wire was used. In both cases the joints were to present a closely compact and a mechanically impeccable composure.

The experiments have been done with an electronically controlled TIG welding machine, which have properties for wide range adjustments regarding electric parameters and welding time. High purity argon was used as shielding gas. Experience showed that laminar flow of argon gas at little speed is the most convenient, because it does not disturb the plasma arc. Also, W-electrodes with 1.6 mm diameter proved the best choice, since they presented differences according to their alloy type, tip angle, tapering and surface roughness [3]. In Table 1 and Figure 1 are presented the materials and a few characteristic forms of W-electrodes in their original state. This present report does not refer to any tip geometry effect.

Results and discussion

The unalloyed W-electrodes are practically unsuitable for welding, because its arc ignition characteristics are quite bad and wears off quickly. According to their morphology the different types of wear presented in Fig. 2 can be classified in the following types: little craters scattered at random, intergranular wear, general pattern of craters on the surface, partial spitting, heavy spitting and partial melting of the wolfram electrode.

The experiments performed with thorium-oxide alloyed electrodes in the case of Ni-Mn wire and stainless steel showed a very good arc ignition, but the quality was lowering with the electrodes wear, and after approximately 300 welding cycles became unstable. Fig. 2 presents the character and the degree of wear. Also, the usage of electrodes alloyed with thorium is unacceptable due to their radioactive effect [4].

The SEM investigations appears clearly, that the wear of the WL15 lanthanum-oxide alloyed electrode is substantially smaller than of those alloyed with thorium, and also the number of welding cycles, before they show signs of instability, is more than double. Fig. 3 shows the tip's form after the 637th cycle, on which the details of the characteristic zones on the electrode's surface are also visible. These zones that differ very much in their chemical composition and morphology distinctly separate from each other. Classified as follows, from the cylindrical part to the tip:

- Welding filler metal's spit and burnt oxide is deposited in the farthest position.
- Filler metal's metallic spit.

Type	Alloying (wt-%)	Color code
WP	Unalloyed	Green
WC20	CeO ₂ =1.80-2.20	Gray
WL10	La ₂ O ₃ =0.90-1.20	Black
WL15	La ₂ O ₃ =1.30-1.70	Gold
WL20	La ₂ O ₃ =1.80-2.20	Sky-blue
WT10	ThO ₂ =0.80-1.20	Yellow
WT20	ThO ₂ =1.70-2.20	Red
WT30	ThO ₂ =2.80-3.20	Violet
WT40	ThO ₂ =3.80-4.20	Orange
WY20	YtO ₂ =1.80-2.20	Blue
VX	Combined RE oxides	Yellow-green
WZ3	ZrO ₂ =0.15-0.50	Brown
WZ8	ZrO ₂ =0.70-0.90	White

Table 1. Tungsten electrodes according to ISO 6848 and EN26848 standards

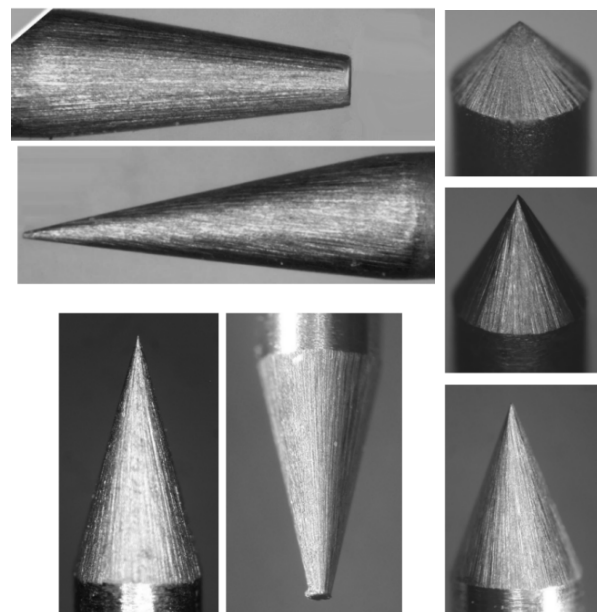


Fig. 1. Pre-sharpened electrode tips with different tip-angle and surface quality

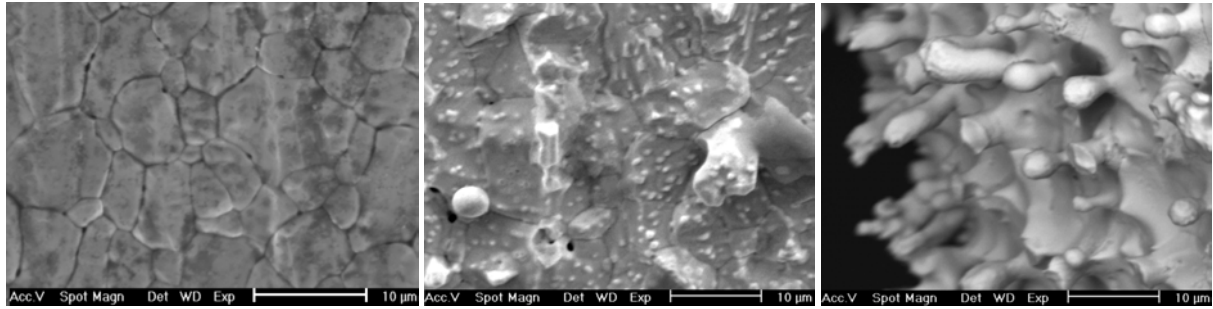


Figure 2. Electrode wearing: intergranular, partial and heavy spitting.

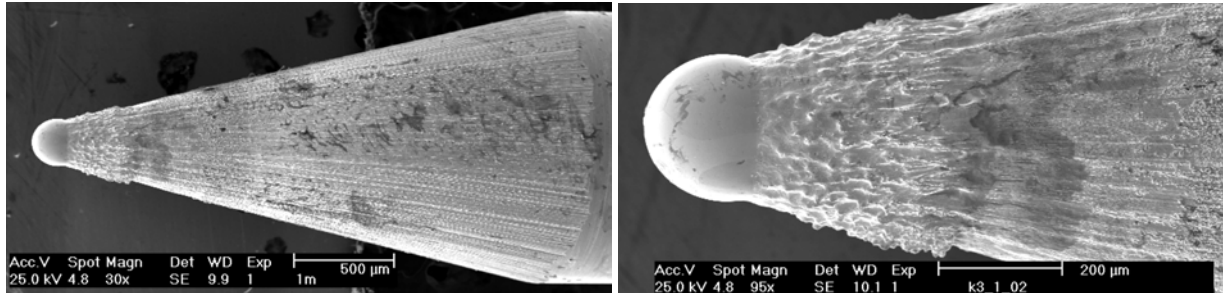


Figure 3. Wearing of WL15 "Gold" electrode after 637 arc-spot cycles.

- Alloying oxides deposited in a thick pond-like formation.
- Melted tip, which is completely free of alloying components, and also what left over.

It has to be highlighted the fact, that the 'gold' electrode presented an excellent arc ignition and wear resistance that led to stable functioning results even when a considerable amount of Ni and Mn impurities appeared on the electrode's tip's surface, due to polarity switch.

Systematic evaluation of the great number of performed experiments showed, that the wear of the alloyed W-electrode is occurring with the formation of wearing zones. This was foreseeable, since it was previously presented regarding the characteristic types of unalloyed electrodes. The zones can be well observed in Fig. 4, which presents the picture of a completely pointed WT15 electrode, made after 20 welding cycles. The zones that appear after 20 cycles are similar with the ones that have already been determined and presented in the case of an electrode after 637 cycles.

However, in the case of the latter these zones were more marked, but overlapping at the borders. It has to be mentioned, that the impurities, which appear due to the welding filler metal, as well as the melting of the tip appear right after the first welding cycle. The melted globe is slowly increasing in size with the increasing number of welding cycles.

Conclusions

Considering the objective that was set, formulated in the abstract as: finding the optimum regarding the quality of the welded joints of lamps, the conducted experiments have been successful. The electrode's wear characteristics, so important from the joint's quality's point of view have also been determined, and possessing the necessary information it was possible to choose the right type of electrode and the proper welding technology. Regarding the wearing process of the alloyed electrodes it has been confirmed, that characteristic wearing zones are formed on the conical part, which are similar to the unalloyed ones. And these are well distinguishable according to the distance from the tip, and show a completely different wear character.

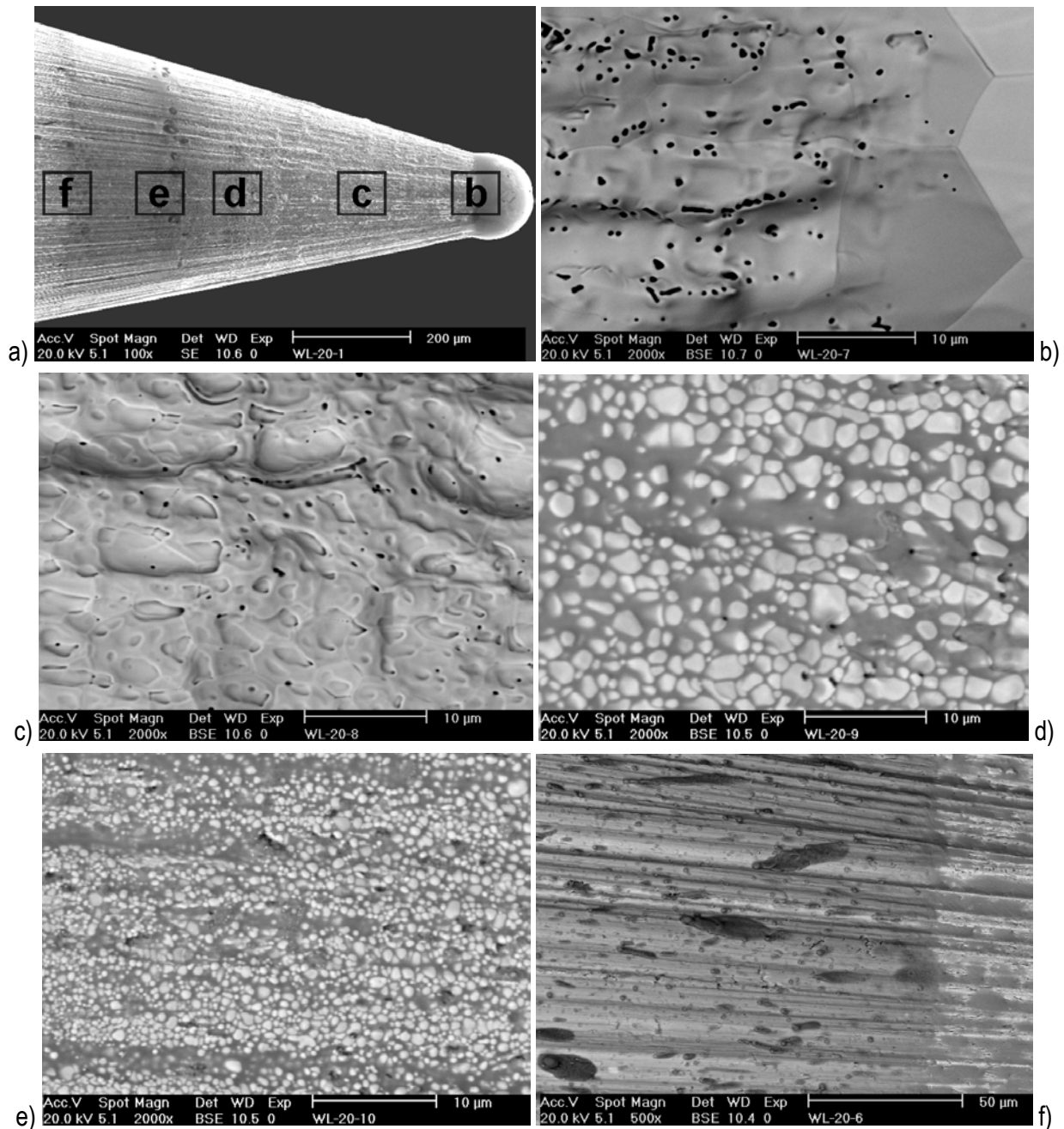


Figure 4. Contamination of WL15 type ("Gold") electrode after 20 arc-spot cycles.

The micro-TIG welding experiments, performed with different W-electrodes, showed that the wearing process is an extremely complex one. The characteristics of major influence, disregarding the electrical parameters of welding, are the following: alloy type and alloy quantity of the W-electrode, arc length, shielding gas velocity and flow pattern and form of the electrode tip.

Long-term experiments confirmed that the thoriated electrode has the best ignition, but its deterioration is spectacular. The cerium-electrode's ignition is average; its lifetime is short and wears fast. The lanthanum-electrode has good ignition, outstandingly good lifetime and it is very resistant against wearing. At the same time, it should be added that the examination of the wearing process still has many other tasks to offer, for example: the electrical parameters, the anode's component materials, and so on.

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