

CORROSION OF AUXILIARY ELECTRODES IN ELECTROCHEMICAL PROCESSES USING AC

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Electrochemical machining (ECM) or electrochemical shaping in its different forms (e.g. cavity sinking, drilling, trepanning, deburring) is one of the non-conventional methods of metal removal. The fact that this method is independent from mechanical material parameters like hardness and strength makes it particularly suitable for shaping refractory metals.

Usually direct current (DC) is applied for anodic metal dissolution. In the case of materials causing problems due to pronounced passivation different forms of current (e.g. monopolar or bipolar pulses) have been evaluated.

To dissolve tungsten carbide unipolar anodic pulse current was found to be advantageous. Even better dissolution rates were achieved by using a sequence of positive and negative rectangular pulses (bipolar pulse current) [1,2]. This type of current is difficult to use in most industrial applications. For this reason, experiments with alternating current (AC) were conducted, e.g. for the dissolution of nickel-iron alloys [3]. It was found that using AC instead of DC resulted in a superior current efficiency. Even metals belonging to the platinum-group could be dissolved by AC treatment [4].

The problem arising with the application of AC is caused by the fact that in this case (different to DC methods) not only the workpiece (working electrode) is exposed to anodic dissolution (corrosion), but also the tool (auxiliary electrode). This results in a metal removal from the surface of the auxiliary electrode and consequently a dimensional change of the tool. Reports of stability tests show quite different and even contradictory results: one group of authors describes graphite as a stable material under AC conditions [1] while another team [5] regards graphite as non-stable under these circumstances. It is evident that stability of a material serving as auxiliary electrode depends on experimental parameters like temperature and the chemical nature of the electrolyte system. In the best case the anodic dissolution of the material is disabled to such an extent that at positive potentials oxygen evolution occurs rather than oxidation of the metal (or other conductive material).

This paper deals with a series of experiments evaluating the stability of a number of metals and composites in an alkaline system in combination with a molybdenum working electrode and alternating current. To obtain a clearly defined current density the test materials were embedded in epoxy resin and the free planar surface (0.3 to 0.5 cm²) was ground and polished. The working electrode was made from molybdenum sheet and covered with an insulating epoxy resin too, leaving a free surface area of 4 cm². The electrodes were immersed in 4 molar KOH serving as electrolyte. The distance between the electrodes was 10 mm (max.). Before the electrodes were connected to the AC current source the weight was determined by means of an analytical balance. During the experiment measurements of the main parameters influencing the result were conducted:

voltage, current, time, and temperature. To obtain comparable results for all test materials a current density of 5 A.cm⁻² was chosen and this current density was kept constant for the whole experiment.

The following table shows the names, chemical compositions, and densities of the investigated materials.

Table 1: Auxiliary electrode materials

Material	Composition wt%	Density g.cm ⁻³
Nickel	Ni, 99.9	8.9
WC/ZrC-cermet	51WC/40ZrC/9Co,Ni,Cr	9.7
Ti(C,N)-cermet	62Ti(C,N)/10Ta(Nb)C/15WC/13Co,Ni,Cr	6.5
Nickel L314	Ni41Fe32Cr20Mo2.5Cu2	7.9
ZrN-cermet	83ZrN/17Ni,Cr	7.5
TiN-cermet	80TiN/10Ti/10Ni	5.5
CoCr-alloy	Co65Cr27Mo6	7.0
HE5S	synth. graphite	~ 1.7
HE41	synth. graphite	
HE83	synth. graphite	
gold – dental alloy	Au/AgCuPdZn	18.5
TiB ₂ -cermet	unknown	4.6

Fig. 1 displays the linear dissolution rate (in mm.h⁻¹) for all the materials tested under the previously described conditions.

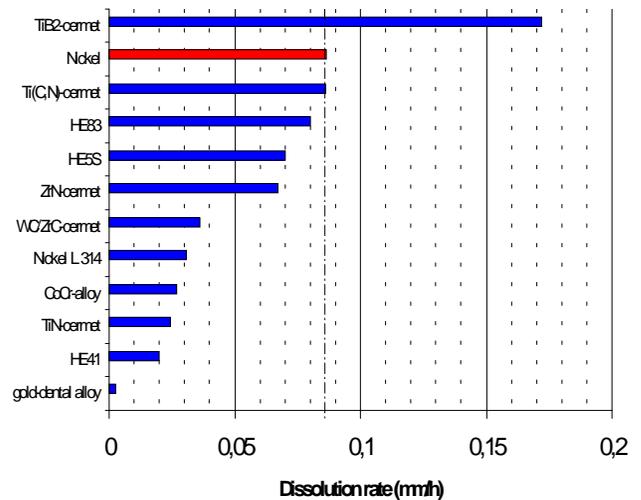


Fig. 1: Dissolution rates of test materials

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