

# INVESTIGATION OF THE COMPOSITION AND PROPERTIES OF ELECTROLYTES ON CHLORIDE AND NITRATE BASE DURING ECM OF HEAT RESISTANT ALLOYS

8<sup>th</sup> International Workshop on Surface Engineering &  
4<sup>th</sup> International Workshop on Applied and Sustainable Engineering

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ECM is widely used in the production of gas turbine engines with high demands to the quality and accuracy of the details. Performance, accuracy and quality of the ECM are largely determined by the stability of the electrolyte composition and its parameters during processing. The hexavalent chromium content in the electrolyte is important parameter from an environmental point of view. The dissolution of alloy generates compounds of trivalent and hexavalent chromium depending on the alloy composition and the electrolyte type. Thus such compounds are redistributed between the electrolyte and sludge sediment.

The dynamics of chromium compounds accumulation in the electrolyte at ECM of EI 893 – nickel based and EI 612 - the iron-nickel based superalloys was studied. The physico-chemical parameters depending on electrolyte composition changes were recorded simultaneously with its analysis.

The sludge accumulation in the electrolyte was carried out using the laboratory equipment simulating conditions ECM (maintaining small interelectrode gaps sufficiently high operating current density, the electrolyte circulating feed mode while stabilizing its temperature by a heat exchanger).

Electrolyte volume was strongly controlled to avoid losses in order to increase the accuracy of its composition determination. Dissolution of the sample was carried at a current density of 2 A/cm<sup>2</sup> for a certain time. Then the amount of dissolved metal was determined, sampling for chemical analysis of the electrolyte at the moment was done and the product concentration in the electrolyte was determined. Determination of chromium, nickel and iron concentration was carried out separately for the precipitate and the filtered solution. We calculated the dissolution rate of the alloy and made allowances for the remaining amount of electrolyte. The procedure is repeated until a substantial electrolyte contamination will be achieved (comparable to service contamination ~10 A·hour/l).

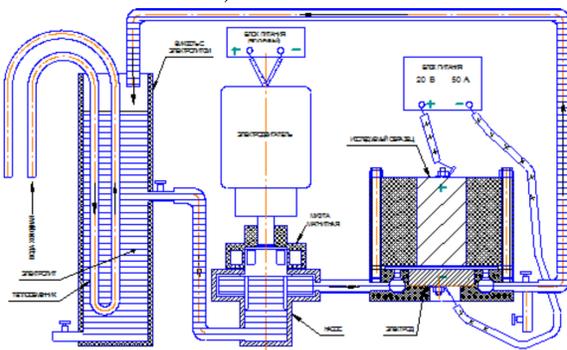


Fig. 1 Experimental installation for anodic dissolution studies under conditions of ECM with sludge accumulation

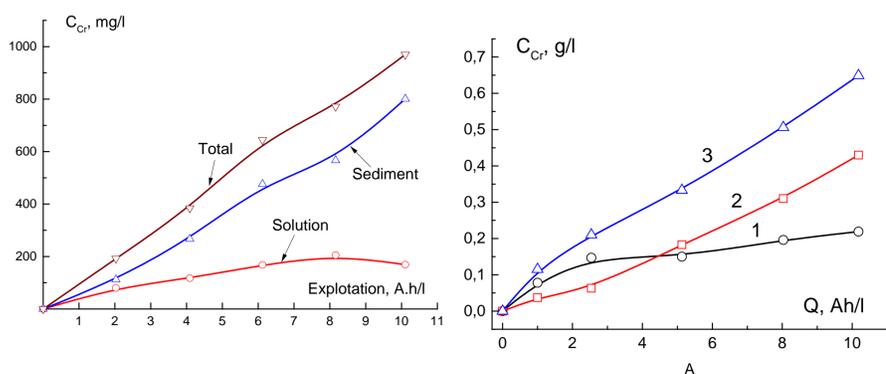


Fig. 2 Distribution of chromium between solution and sediment in NaNO<sub>3</sub> (left) and NaCl (right) electrolytes

Anodic dissolution of the alloys varies depending on the alloy composition and the electrolyte type. In the nitrate electrolytes dissolved chromium exist into solution predominantly in the hexavalent form, and chlorides - trivalent. Steel EI 612 in the nitrate and mixed nitrate-chloride electrolytes dissolves with a variable current efficiency. EI 893 alloy dissolves with essentially the same high speed regardless of the composition of the electrolyte. In all cases ECM of the alloys occurs with increasing accumulation of hexavalent chromium in the solution, while the trivalent chromium is present only in the precipitate.

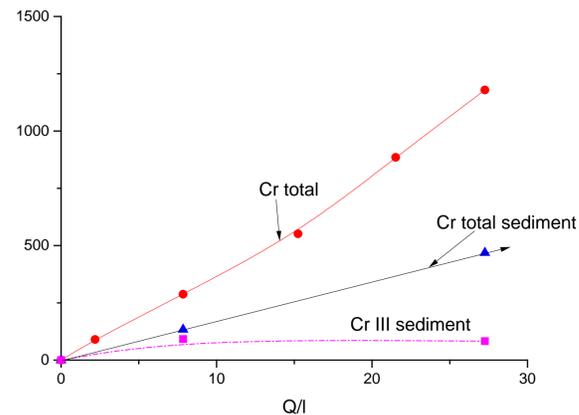


Fig. Distribution of dissolved chromium in NaCl electrolyte after ECM of EI 612 alloy (iron-nickel based)

It has been established that the concentration of nitrate and chloride ions does not change in the specified range of operation, however, due to the change in the pH of the solution (from 6.5 in the initial treatment period to ~ 8.8), the electrical conductivity varies negligible, but then remains near the stationary values. Qualitative modification of the composition of the solution (liquid phase) occurs only due to the accumulation of bichromate ions as a result of anodic dissolution of chromium. However, no more than 25% of the total dissolved chromium is converted into a soluble form in the electrolyte as a result of: a) partial dissolution of chromium in the form of Cr (III), followed by precipitation in the form of hydroxide in the solid phase; b) adsorption of bichromate ions on a precipitate consisting of a mixture of nickel and chromium hydroxides. After 10 A · h / l, the sediment accounts for about a third of the total volume of the installation tank.

Accumulation of hexavalent chromium in the solution and the precipitate depends on the sorbent ability of the sludge, consisting almost entirely of nickel hydroxide or a mixture of hydroxides of nickel and iron. However, the resulting sludge is insufficient for the full adsorption of chromium dissolved and remains in solution. A characteristic feature of ECM of the iron containing alloy in the nitrate or mixed electrolyte, unlike the alloy EI 893, is the preferential accumulation of CrVI in the solution (at a similar ratio of trivalent and hexavalent chromium compound amounts).

The reason for this behavior on the iron-nickel alloy can be high oxidizing ability in nitrate solution formed Fe<sup>+2</sup> and transfer of the dissolving chromium in the hexavalent state. In this case sludge as absorbing agent is insufficient to hold the dichromate ions, and they go into solution.

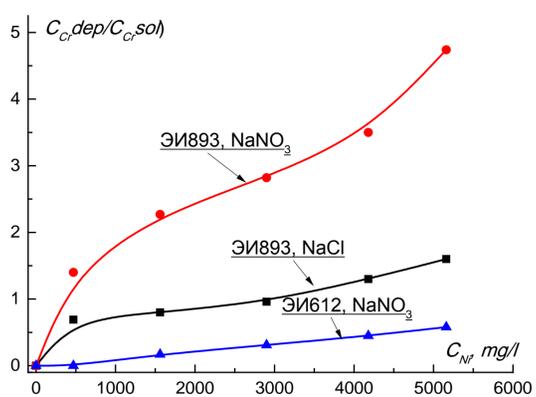


Fig. Correlation between the chromium concentration in deposited sludge and solution in different electrolyte in dependence of dissolved nickel concentration

The received outcomes have formed the basis of guidelines on development of the preparation and storing of electrolyte station for ECM of turbine engine blades from heat resistant alloys. These results also are necessary for determination of optimal pulse ECM parameters within micro-and a nanosecond band for the purpose of improvement of machining process localization.

This work was supported by the Academy of Sciences of Moldova (project № 15.817.02.05.A) and project H2020 Smartelectrodes (778357).