Analysis of the Vortex Motion of Reaction Products during Electrolytic Deposition of Nickel in a Magnetic Field

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Introduction

We observed and analyzed the rotational motion of the electrolyte during the electrolytic deposition of nickel on a ferromagnetic mesh electrode in an external magnetic field. The characteristic frequencies of rotation of the electrolyte were found by optical methods developed by us earlier. The proposed method allows us to determine the frequency dependences without introducing marker particles or other changes of the electrolyte structure or the character of the reaction.

Experiment and Results

The experiment on electrolytic deposition of nickel on a steel mesh electrode in a magnetic field was carried out. The glass cell with electrolyte having sizes 26 mm by 24 mm, 37.5 mm high, 24 mm of electrolyte layer, was placed between the poles of an electromagnet creating a field of H=515 E. The cathode consisted of a steel mesh with a cell side of 0.83 mm and a wire diameter of 0.3 mm. The anode is a 0.1 mm thick nickel plate. The height of the electrolyte layer was 24 mm. The current during electrolysis was I=1.81 A, the current density was 0.414 A/cm^2. During the reaction, a rotational motion of the electrolyte was observed, similar to that described in works [1,2]. To study the characteristics of rotation, we used the method developed by us in work [3]. The reaction process was filmed with a video camera. The shooting mode was 30 frames per second with a size of 640 by 480 pixels. The shooting was carried out under illumination with a white LED lamp, only brightness was used for processing – the image was converted to grayscale. A sequence of 2048 frames (~ 68.3 s) was analyzed. For the analysis, an area inside the cuvette with a size of 90 by 140 pixels was selected, since the analysis of the entire image shows that the greatest changes in intensity occur in the area of release of gaseous reaction products. For further processing, a map of the area of the greatest changes was made, the threshold value was taken at 0.5 from the maximum, 478 pixels with an intensity above the threshold were selected on the map. After carrying out the Fourier transform (to reduce the distortion of the spectrum, a Hamming window was used), the spectrum of characteristic frequencies of electrolyte rotation was obtained, on which maxima of 0.161 Hz, 0.337 Hz and 1.113 Hz were observed.

Fig. 1. Cuvette with an electrolyte in a magnetic field and the difference image obtained by processing the minima and maxima of the intensity of the sequence of 2048 frames.

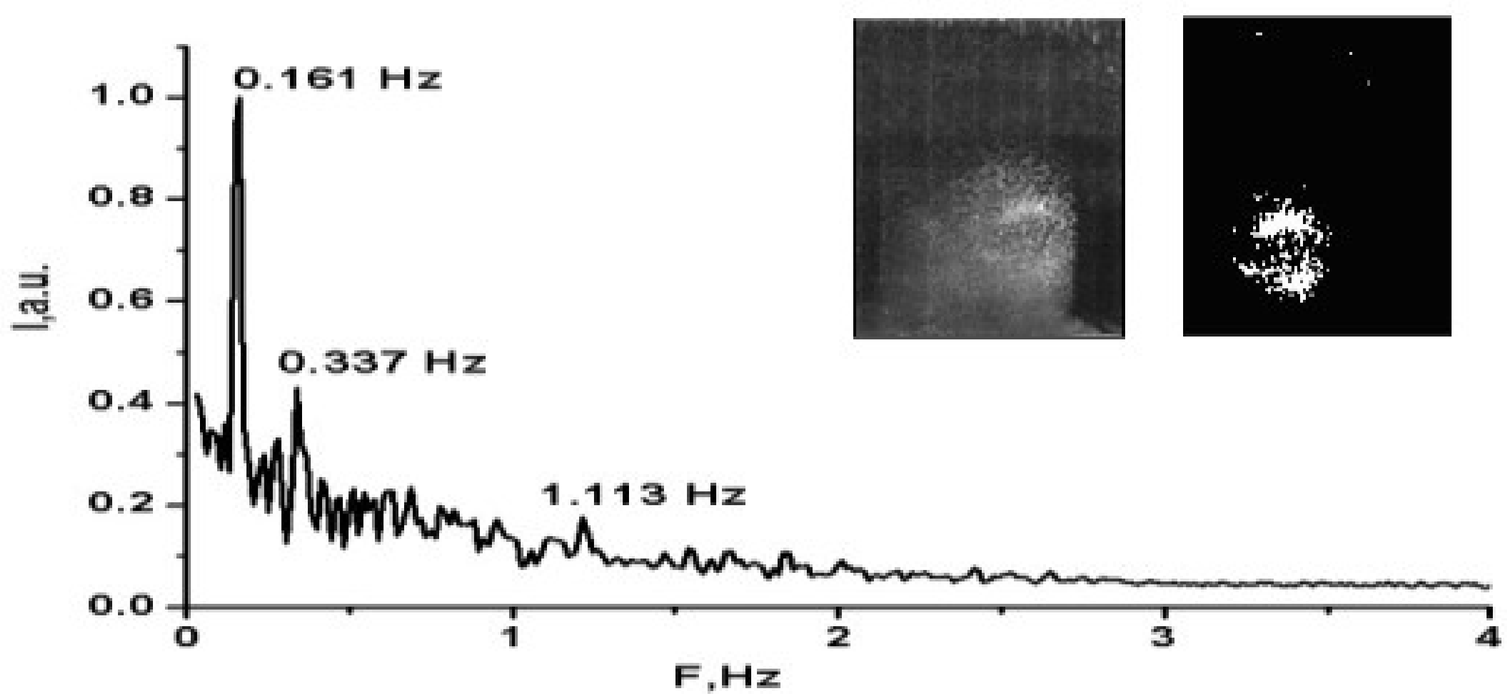

Fig. 2. Spectrum of electrolyte rotation frequencies. The inset shows the difference image of the region inside the cuvette and its brightest part of 478 pixels, for which the calculations were carried out.

Conclusions

The investigations carried out have shown the presence of a rotational motion of the electrolyte during the deposition of nickel in a magnetic field. The characteristic frequencies of rotation of the electrolyte were found. This rotation is in many aspects similar to the processes occurring during the dissolution of a steel ball in nitric acid in an external magnetic field [3]. To determine the dynamic characteristics, a video processing technique was used that does not introduce distortions during the reaction. This technique, with some modifications, can be used to study the frequency characteristics of the motion of liquids, gases and small objects without directly affecting the medium under investigation.

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