

Magnetohydrodynamic stirring microdevice in a magnetic field

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Abstract

Mixing process was investigated as a function of metal element size, external magnetic field magnitude and distance from metal cylinder surface. Investigation results have shown an application of magnetic field is possible instrument for electrolyte flow parameter change. Magnetohydrodynamic mixer of an electrolytes solution was proposed on investigation result base. The advantages of proposed device are simple construction and absence of energy consumption.

Keywords: magnetic field; magnetohydrodynamic mixing

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1. Introduction

During several decades there is a growing interest to the phenomena occurring in electrolyte solutions under the influence of a magnetic field. One of the most well-investigated effects is stirring (mass transfer) in the combined electric and magnetic fields [1-4]. It is well-known [5-9] that mixing usually leads to acceleration or change of character of chemical and electrochemical processes occurring in electrolytes [5-9]. A stirring process is widely used for heat, mass transfer and biochemical process intensification, metal extraction from solution by microorganisms in the biometallurgy, waste water purification from heavy metals by biosorbents. But one require additional power sources, complex device construction. It is actual to develop new inexpensive mixing methods and devices. The phenomenon of magnetohydrodynamic electrolyte mixing has served as a basis for development of improved methods of magnetoelectrochemical codeposition of several metals and inert particles, obtaining high quality of deposits, creation chaotic magnetohydrodynamic mixing of electrolytes (such as Lagrange chaos) at very small Reynolds numbers [10]. In the paper [10] need of development of mixing methods for acceleration of chemical and biological processes in microvolumes is noticed. Recently the effect of multivortex electrolyte stirring was found in the vicinity of a solitary electrode in a magnetic field without application of external electrical field [11,12]. Efficiency of magnetohydrodynamic mixing without external electric field was shown for intensification of biosorption of copper ions, corrosion acceleration of steel in the solution of nitric acid and control of the rate of corrosion process in electrolytes in a magnetic field [13-14].

1.2. Experimental part

The mixing device of micro-volumes of electrolytes without external electric field is proposed in the paper. The advantages of proposed device are simple construction and absence of power supply. Magnetohydrodynamic mixer based on metal matrix injection into the electrolyte solution. Proposed device consists of reservoir for electrolyte, metal matrix, nonmagnetic and nonreacting with electrolyte solution holder of metal matrix. Uniformly distributed steel cylinders of carbon steel were used as metal matrix. An aqueous nitric acid solution was used as a model electrolyte. The device was placed into a steady magnetic field. Electrolyte flows are emerged in the vicinity of metal matrix at a magnetic field switching. Modern technologies allow to use strong magnetic fields, for example, permanent magnet application. The permanent magnet application advantages are absence of power supply expenditure and simple construction. Thus energy consumption is minimal at a permanent magnet using.

Mixing intensity was investigated as a function of metal element size, external magnetic field magnitude and distance from metal cylinder surface.

Investigation results have shown significant dependence of flow velocity on magnetic field magnitude, metal element size and distance from metal element surface. The diameter of experimental cylinder is equal to 0,540 μm . As shown in Fig. 1, flow velocity increases with magnetic field magnitude increasing. By this reason magnetic field in magnetohydrodynamic mixer should be maximal.

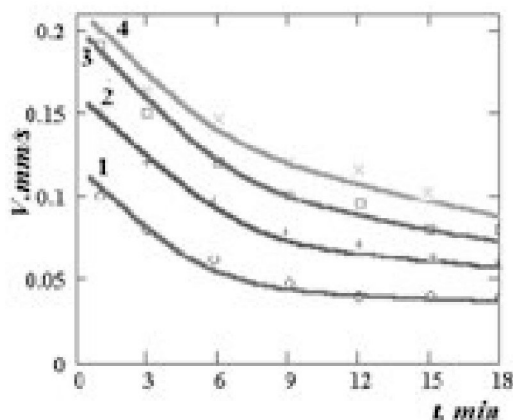


Fig.1 Velocity dependence of nitric acid solution flow in the vicinity of steel cylinder on external magnetic field magnitude: curve 1 corresponds to – 1000 Oe; 2 – 2000 Oe; 3 – 3000 Oe; 4 – 4000 Oe.

Dependence of flow velocity of 7% nitric acid solution on steel cylinder diameter in the 3000 Oe magnetic field is depicted in Fig.2. Flow velocity increases with steel cylinder diameter increasing. The dependence should be taken on account at the creation of metal matrix.

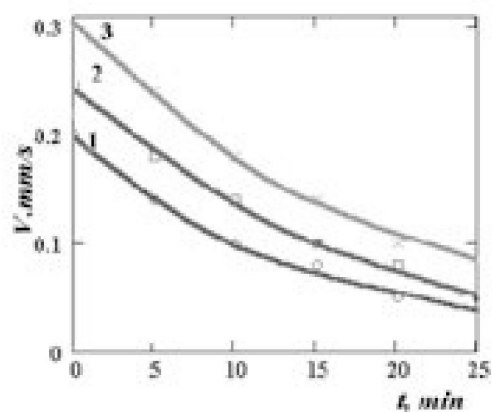


Fig.2 Velocity dependence of nitric acid solution flow in the vicinity of steel cylinder on steel cylinder diameter in the 3000 Oe magnetic field: curve 1 corresponds to – 540 μm ; 2 – 653 μm ; 3 – 1000 μm .

Velocity dependence on distance from cylinder surface in the 3000 Oe magnetic field is depicted in Fig. 3. We can see from Fig. 3 that above described dependence has a maximum peak.

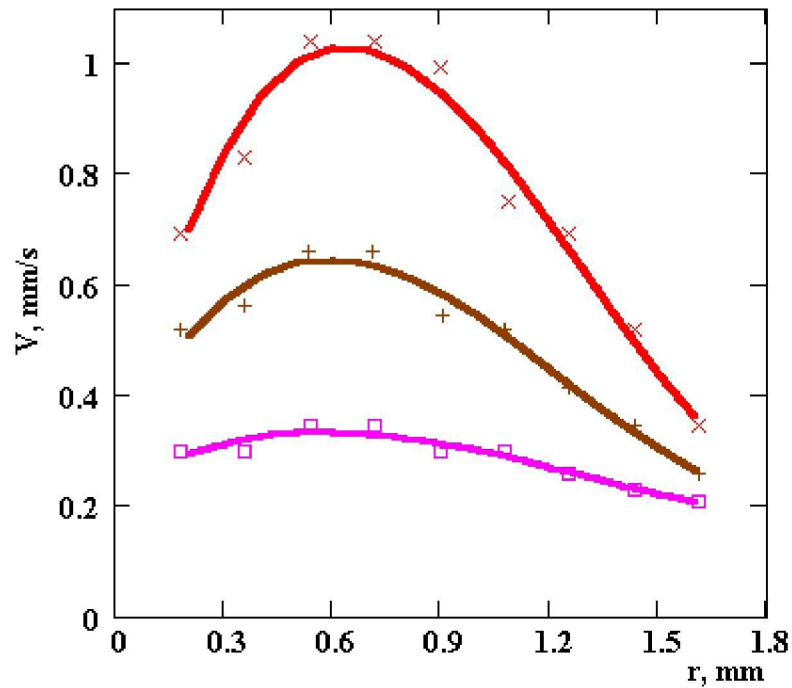


Fig.3 Velocity dependence of nitric acid solution flow in the vicinity of steel cylinder on distance from steel cylinder surface in the 3000 Oe magnetic field: curve 1 corresponds to – first minute; 2 –second minute; 3 – third minute.

In our case, velocity maximum peak corresponds to 0.6 mm distance from steel cylinder surface. By this reason distances between metal cylinders were chosen equal to 2-3 cylinder diameter in the proposed device.

1.3. Conclusion

Results of the investigation and early papers [13-16] have shown dependence of electrolyte flow velocity and electrolyte flow geometry in the vicinity of metal element on magnitude and direction of external magnetic field, parameters of metal elements and electrolytes. Thus an application of a magnetic

field and magnetic field parameter change are possible instruments for change of electrolyte flow parameter.

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