Magnetohydrodynamic mixer of an electrolyte solution

Svetlana Gorobets[1], Oksana Gorobets[2]*, Irina Goyko[1], and Sergiy Mazur[2]**

[1] National University of Food Technologies, 68, Vladimirskaya st., Kiev 01033, Ukraine
[2] Institute of Magnetism of NAS of Ukraine, 36-b, Vernadskogo av., Kiev 03142, Ukraine

Received 27 June 2004, accepted 14 October 2004
Published online 20 December 2004

PACS 47.27.Te, 47.65.+a, 61.66.Dk, 68.05.Cf, 68.08.De

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 results base. The advantages of proposed device are simple construction and absence energy consumption.

1 Introduction

Magnetohydrodynamic mixing in the vicinity of metallic surface in the electrolytes in the combined magnetic and electric field is a well-known and widely used phenomenon [1–3]. Necessity of micro-device constructing for high-quality mixing of liquid micro-volumes in the chemical and biological application is noted in paper [2]. 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 the magnetic field [4–6].

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 nozzle injection into the electrolyte solution. Proposed device consists of reservoir for electrolyte, metal nozzle system, nonmagnetic and nonreacting with electrolyte solution holder of metal nozzles. Uniformly distributed steel cylinders of carbon steel were used as metal nozzle system. 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 nozzle at a magnetic field switching. 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 flow velocity dependence 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 increase with magnetic field magnitude increasing. By this reason magnetic field in magnetohydrodynamic mixer should be maximal.

** Corresponding author: e-mail: gor@nuft.kiev.ua, Tel.: +38-044-220-93-55, Fax: +38-044-424-10-20

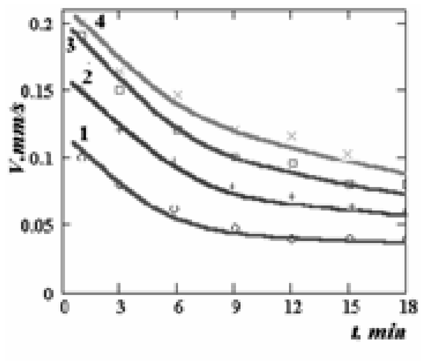

Fig. 1 Velocity dependence of nitric acid solution flow in the steel cylinder vicinity on external magnetic field magnitude: (1) 1000 Oe; (2) 2000 Oe; (3) 3000 Oe; (4) 4000 Oe.

Flow velocity of 7% nitric acid solution dependence on steel cylinder diameter in a 3000 Oe is depicted in Fig. 2. Flow velocity increase with steel cylinder diameter increasing. The dependence should take to account at the creation of metal nozzles system.

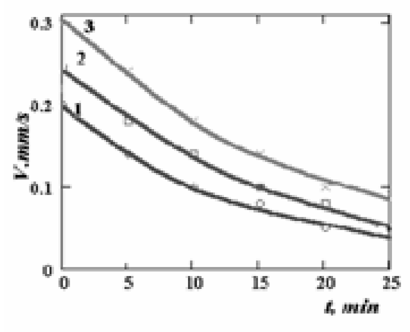

Fig. 2 Velocity dependence of nitric acid solution flow in the steel cylinder vicinity on steel cylinder diameter in a magnetic field: (1) 540 μm; (2) 653 μm; (3) 1000 μm.

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

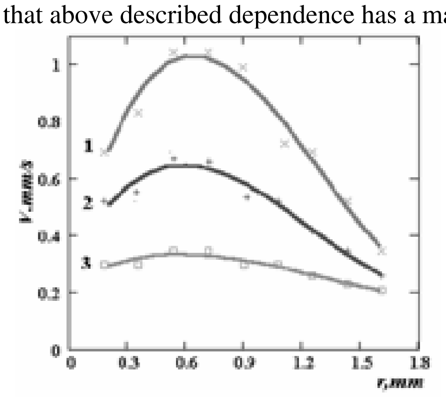

Fig. 3 Velocity dependence of nitric acid solution flow in the steel cylinder vicinity on distance from steel cylinder surface in a magnetic field: (1) first minute; (2) second minute; (3) third minute.

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

3 Conclusion

Investigation results of paper and early papers [4–10] have shown dependence of electrolyte flow velocity and electrolyte flow geometry in the metal element vicinity on magnitude and direction of external magnetic field, parameters of metal elements and electrolytes. Thus an application and parameter change of magnetic field is possible instrument for electrolyte flow parameter change.

References

[1] N. Leventis and X. Gao, J. Phys. Chem. B **103**, 5832 (1999).
[2] J.M.D. Coey and G. Hinds, Europhys. Lett. **479**, 267 (1999).
[3] T.Z. Fahidy, Progr. Surf. Sci. **68** (2001).
[4] Yu. I. Gorobets and S.V. Gorobets, Magnetohydrodynamics **3** (2000).
[5] S.V. Gorobets, O.Yu. Gorobets, and N.P. Bandurka, Fiz. Met. Metalloved. **92** (2001).
[6]S.V. Gorobets, O.Yu. Gorobets, and S.A. Reshetnyak, Magnetohydrodynamics **39**, 2 (2003).
[7] S.V. Gorobets and O.Yu. Gorobets, Magnetohydrodynamics **38**, 4 (2002).
[8] S.V. Gorobets, O.Yu. Gorobets, and V.Yu. Gorobets, J. Mol. Liq. **105**, 3 (2003).
[9] S.V. Gorobets, O.Yu. Gorobets, and S.A. Reshetnyak, J. Magn. Magn. Mater. (2003) (to be published).
[10] S. Gorobets, O. Gorobets, and T. Kasatkina, J. Magn. Magn. Mater. (2003) (to be published).
[11] S. Gorobets, O. Gorobets, and I. Goyko, Abstracts of the 9-th JOINT MMM / Intermag conference, Anaheim, California. HS-15 (2004).
[12] V.G. Baryakhtar, Yu.I. Gorobets, and O.Yu. Gorobets, J. Magn. Magn. Mater. (2003) (to be published).