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Studies of mass transfer at a spiral-wound woven wire mesh rotating cylinder electrode

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ABSTRACT

Mass transfer has been studied at rotating cylinder electrodes fabricated with spiral-wound woven-wire meshes using reduction of copper as a test reaction. The experimental data were correlated by an empirical expression between the Sherwood number and the Reynolds number, both regarding the hydraulic diameter as a characteristic length. It was found that the Sherwood number was dependent upon the Reynolds number to the power of 0.521. An enhancement factor was adopted to compare the efficiency of the new rotating cylinder electrode with previous three-dimensional rotating cylinder electrodes. The results showed that the new type has a mass-transfer enhancement factor 2.3 times higher than those obtained with smooth rotating cylinder electrodes under the same conditions.

1. Introduction

The rotating cylinder electrode reactor (RCER) has many features that are not shared by other electrochemical reactors. These include an easily operable compact design, uniform current and potential distributions, and homogeneity of the shear stress at the electrode surface, which enable control of the mass transfer rate and operation under continuous conditions [1–4]. Therefore RCERs have been applied in various industrial sectors, including metal ion recovery [5,6], corrosion [6,7], electrosynthesis [7], alloy formation [5,7], effluent treatment [8,9], and Hull cell studies [1,10].

The primary application of RCERs is in the treatment of effluents due to their good mass-transfer conditions created by the movement of the electrode [11]. The incorporation of turbulence promoters has been suggested to further increase the space– time yield. Thus, Kappesser et al. [12] investigated mass transfer at rotating cylinders with staggered diamond knurls machined on their surfaces. Sedahmed et al. [13] performed mass transfer investigations at rotating finned cylinders, where fins were prepared by cutting longitudinal rectangular grooves in the cylinders. Makanjuola and Gabe [14] studied the mass transfer at V-grooved cylinders and extended their investigation to pyramidal knurling and wires or meshes wound to a cylindrical rotating electrode [15].

Another strategy to obtain a high space–time yield is the use of a rotating three-dimensional electrode. Thus, Kreysa and Brandner [16] studied the behavior of a rotating packed bed cell with radial flow of the electrolyte. By using the reduction of ferricyanide on nickel plated steel spheres or silver deposition on graphite particles, the mass-transfer coefficients were determined as a function of the rotating Reynolds number and the channel Reynolds number. Kreysa [17] found that the Sherwood number was dependent upon both the Reynolds number and the channel Reynolds number to the power of 0.58. Nahle´ et al. [18] reported mass transfer data for rotating cylinder electrodes of reticulated vitreous carbon (RVC). Using copper deposition for a test reaction, they found that the limiting current related with velocity to the power of 0.55–0.71 based on the porosity of the RVC. They concluded that the mass transfer coefficients are comparable to those at a smooth rotating disk electrode of the same diameter. This enhancement of the mass transfer is mainly due to the higher specific surface area of the RVC.

Grau and Bisang [19] investigated the performance of rotating cylinder electrodes of expanded metal. Adopting ferricyanide reduction as a test reaction, they found that the Sherwood number was dependent on the Reynolds number, both defined in terms of the hydraulic diameter as a characteristic length, to the power of 0.63. To consider the effect of the geometry of the expanded metal, two additional dimensionless parameters were inserted in the empirical expression. Grau and Bisang [20] studied the performance of rotating cylinder electrodes of wedge wire screen. Using the cathodic reduction of ferricyanide as a test reaction, they reported that the Sherwood number was dependent on the Reynolds number, both defined in terms of the internal slot opening as a characteristic length, to the power of 0.63. They reported an

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