This Week's Citation Classic

Newman J. Current distribution on a rotating disk below the limiting current. *J. Electrochem. Soc.* **113**:1235-41, 1966.
[Inorganic Materials Res. Div., Lawrence Radiation Lab., and Dept. Chem. Engineering, Univ. California, Berkeley, CA]

In this paper, the distribution of current across the surface of a rotating-disk electrode is calculated for the general case where electrode kinetics, mass-transfer limitations, and ohmic resistance are all significant. [The *SCI*® indicates that this paper has been cited in over 105 publications since 1966.]

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"The rotating-disk electrode is popular for studying electrochemical systems because the mass-transfer characteristics are well understood, and, under mass-transfer-limited conditions, the current density on the disk is uniform. This uniform current density is not achieved at lower currents, however, because the edge of the disk is more accessible than the center as a result of the resistance to current flow in the solution.

"This paper arose in the development of a theory for variable physical properties in the diffusion layer of a rotating-disk electrode.[1] When the theory was compared with experiments,[2] it was discovered that the ohmic potential drop in the solution is important, i.e., the resistance to current flow plays a major role. At this point, however, I only took the time to do the calculation of the ohmic potential drop corresponding to a primary current distribution.[3] In the primary-current-distribution problem, the solution adjacent to the electrode is taken to be an equipotential surface, and the electrode kinetics and mass-transfer effects are neglected. Therefore, as a crude approximation to the total cell resistance, the resistance corresponding to the primary current distribution was added to the kinetic and mass-transfer resistances. In this case, the current density is infinite at the edge of the disk, whereas the mass-transfer-limited current distribution is uniform across the disk. In reality, though, the current distribution will fall between the two, and, therefore, I had concluded that mass transfer, kinetics, and ohmic resistance should all be included simultaneously.

"At the time when the primary resistance paper[3] was accepted, the editor wrote me a letter stating that everything should be included simultaneously, but that it was probably too complicated a problem to solve. Since I had already begun the work, it was not long before I published 'Current distribution on a rotating disk below the limiting current.' The work was expedited by the good computing facilities we had on campus (University of California, Berkeley) and on the 'hill' (Lawrence Berkeley Laboratory). There were no obstacles in publishing the paper. As a result of this paper, I won the Young Author's Prize in 1966.

"A few years later, a student (William Parrish) working with me on a side project solved a similar problem of current distribution on a plane electrode below the limiting current.[4] This paper won us the Young Authors' Prize in 1969.

"The rotating-disk paper is often cited because it showed that it is possible to solve the whole problem, and not just the limiting cases. (In a humorous moment one might wonder whether another reason that the paper is so often cited is simply that it is easier to cite it than it is to understand it and apply it to one's own system.)

"The justification for the methods used in the rotating-disk paper is given in a more sophisticated paper that was written at the same time.[5] This paper was published later, however, because that journal wanted a longer introduction. In a more recent paper, I compiled the solutions to these types of problems for several geometries."[6]

1. **Newman J & Hsueh L.** The effect of variable transport properties on mass transfer to a rotating disk. *Electrochim. Acta* **12**:417-27, 1967.
2. **Hsueh L & Newman J.** Mass transfer and polarization at a rotating disk electrode. *Electrochim. Acta* **12**:429-38, 1967.
3. **Newman J.** Resistance for flow of current to a disk. *J. Electrochem. Soc.* **113**:501-2, 1966.
4. **Parrish W R & Newman J.** Current distribution on a plane electrode below the limiting current. *J. Electrochem. Soc.* **116**:169-72, 1969.
5. **Newman J.** The effect of migration in laminar diffusion layers. *Int. J. Heat Mass Transfer* **10**:983-97, 1967.
6. --------------. Simultaneous reactions at disk and porous electrodes. *Electrochim. Acta* **22**:903-11, 1977.