The 2024 World Congress on
Advances in Civil, Environmental, & Materials Research (ACEM24)
19-22, August, 2024, The K hotel, Seoul, Korea

Using machine learning and artificial intelligence methods to study the current-voltage characteristics of membrane systems

*Kirillova Evgenia[1)] and Kovalenko Anna[2)]

[1)] *RheinMain University of Applied Sciences, Wiesbaden, Germany*
[1)] evgenia.kirillova@hs-rm.de
[2)] *Department of Data Analysis and Artificial Intelligence, Kuban State University, Krasnodar, Russia*
[2)] savanna-05@mail.ru

ABSTRACT

The aim of the investigation is the mathematical modeling of processes that take place in electro membrane systems (EMS). EMS is widely used for purification, separation, enrichment, desalination and concentration of liquid and gas mixtures. EMS are used in chemical, petrochemical, food technology, biotechnology and pharmacy. The current-voltage characteristic (CVC) is an important integral characteristic of the process of transfer of salt ions in EMS, which is considered to be the desalting channel of an electrodialysis machine. The article examines the CVC for the calculation of which, a 2D mathematical model of non-stationary transfer of 1:1 electrolyte in potentiodynamic mode is formulated and numerically solved.

The article is devoted to the use of machine learning and artificial intelligence methods for a theoretical study of the CVC of membrane systems, taking into account: space charge, electroconvection, forced convection, non-catalytic reaction of dissociation/recombination of water molecules, as well as taking into account the presence and absence of spacers. Based on the Gauss theorem, using a mathematical model, a formula for calculating CVC was derived, resistant to random errors and rounding errors, which made it possible, given certain parameter values, for example, the initial speed of forced convection, initial concentration, to stably calculate theoretical CVC. Since each calculation of the CVC for given values of the specified parameters, using mathematical models, has significant computational difficulties and takes several days, the CVC are calculated in a limited range of parameters, for a small set of data, which entails the loss of some important characteristics of the mass transfer process.

We have created new artificial intelligence systems, namely neural networks trained by modern machine learning methods and optimized using genetic algorithms, for the numerical study of theoretical CVC. The creation of neural networks allowed using prediction to obtain the CVC for a wider range of input parameter values than with the help of currently available numerical algorithms. The regularities of the behavior of CVC for various values of input parameters, such as the length and width of the desalination channel, pumping speed, initial solution concentration, current density values, potential jump, has been revealed.

Funding: The study was supported by the RheinMain University of Applied Sciences and the Russian Science Foundation, No. 24-19-00648, https://rscf.ru/project/24-19-00648.

[1), 2)] Professor