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An Empirical Mathematical Model for Predicting Injection Efficiency of Carbon Dioxide for Optimal Geologic Storage

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A series of integrated injection well and geologic formation numerical simulations was performed using a multiphase thermo-hydrological numerical model to evaluate fluid pressure and temperature changes in injection wells for geologic storage of carbon dioxide under various hydrogeological properties of geologic formations (reservoir rocks) and geometries of injection wells. As a result, an empirical mathematical model is presented to predict the injection efficiency (i.e. injection rate and injectivity) of carbon dioxide for optimal geologic storage. The injection rate can be simply calculated as multiplying the injectivity by the fluid pressure difference between the well bottom and the reservoir rock far from the well bottom, whereas the injectivity prediction is more complex. Thus, the numerical simulation results were statistically analyzed to investigate and quantify relationships between the injectivity and the three factors such as hydrogeological properties (porosity, intrinsic permeability) of the reservoir rock, contact area (well diameter, screen length) between the injection well and reservoir rock, and kinematic viscosity (density, dynamic viscosity) of carbon dioxide at the well bottom. From such multivariate linear regression analyses, a set of empirical mathematical equations, which contain all the above-mentioned three factors, were derived to predict the injectivity. The predicted injectivity using these empirical mathematical equations has an excellent linear relationship with the simulated injectivity. Thus, under given hydrogeological properties of geologic formations (reservoir rocks) and geometries of injection wells, both injectivity and injection rate of carbon dioxide can be simply predicted and evaluated using the empirical mathematical model. Therefore, it is expected that the empirical mathematical model suggested in this study can be utilized as reasonable and practical guidelines when more quantitative and rigorous evaluation of the performance of an injection well is required to determine an optimal operation scheme for carbon dioxide injection. This work was supported by the Research and Development Convergence Program funded by the Korea Research Council for Industrial Science and Technology (ISTK), Ministry of Trade, Industry and Energy, Republic of Korea.