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A new definition of a correlation equation for single collector efficiency

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The transport and deposition of colloidal particles in porous media are important phenomena involved in many environmental and engineering problems as, for instance, the use of micro- and nanoscale zerovalent iron, a promising reagent in the field of groundwater remediation [1]. Particle transport and deposition in the proximity of injection or pumping wells and in porous media in general may also be relevant in other fields of chemical and petroleum engineering.

Mathematical models able to predict particles transport and deposition in porous media are often needed in order to design field applications. The basic concept of these models is the single collector efficiency η, which predicts particles deposition onto a single grain of a complex porous medium in terms of probability that an approaching particle would be retained on a solid grain. Many different approaches and equations exist in the literature, however most of them are valid only under specific conditions (eg. specific range of flow rate, particle size, etc.), and predict, for certain parametric conditions, efficiency values exceeding unity, which is, for an efficiency concept, a contradiction [2][3].

The objectives of this study are to analyze the causes of the failure of the existing models in predicting the deposition rate in certain conditions and to modify the definition of collector efficiency in order to have a more general equation.

The definition of collector efficiency, first proposed by Yao at al. [4], is based on the particles deposition onto a spherical grain (the collector) in an infinite domain. It is defined as the ration between the flux of particles that deposit on the grain and the total amount of particles that could reach the collector by advective flux from an area equal to the projection of the spherical grain itself.

In the present work Yao's model has been implemented by COMSOL Multiphysics and solved with an Eulerian approach; particles deposition simulations were run. From these results a new definition of η is proposed, considering all the flux that potentially reach the collector. A new equation, valid in a broader range of parameters (eg. low Pe number, big particle size, etc.), has been formulated starting from the numerical results.

References

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